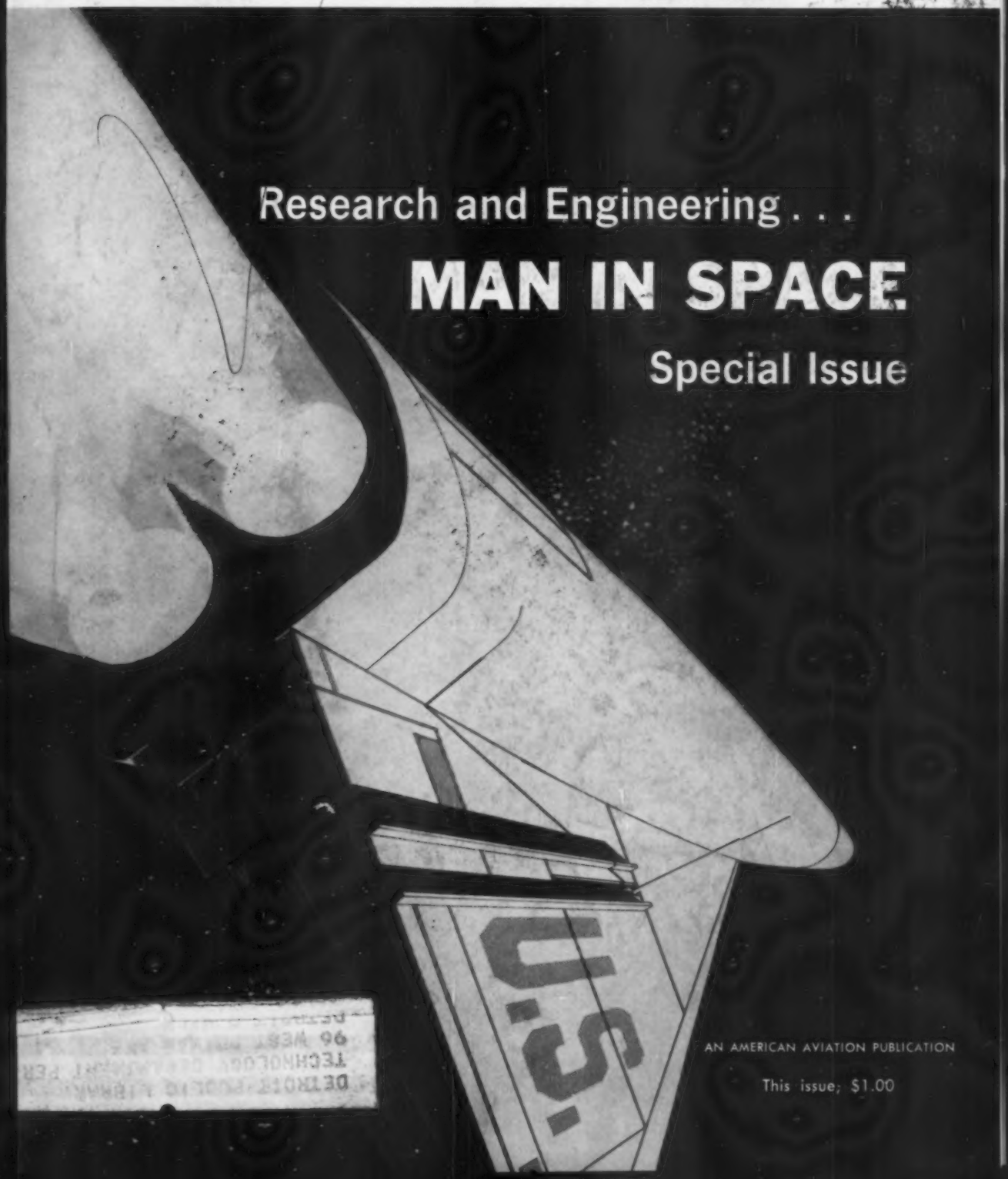
MAY 29, 1961

missiles and rockets

THE MISSILE/SPACE WEEKLY

MAY 31 1961
TECHNOLOGY DEPARTMENT



Research and Engineering . . .

MAN IN SPACE

Special Issue

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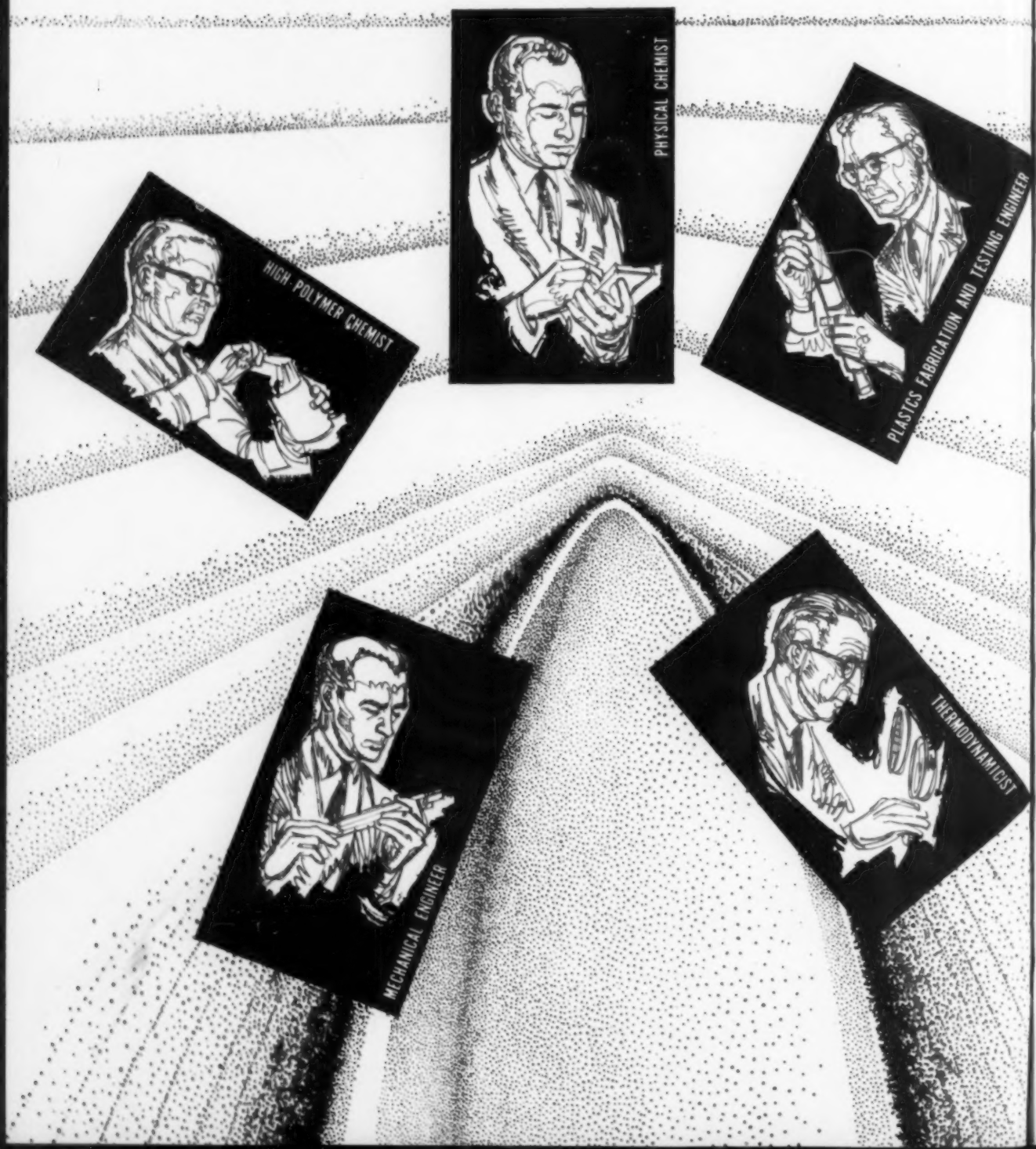
Monsanto

Space-Age Project "HEAT FOIL"

A CHEMICAL EXPEDITION...



...searching for plastics materials that can "take" temperatures of 20,000° F. plus

Monsanto has developed high-heat-resistant resins for laminates that remain intact for upwards of 2-3 minutes at temperatures as high as 20,000° F.; that maintain integrity for 200 hours at 600° F. Under evaluation are plastics laminates that hold promise for rocket nose cones, nozzles, and other components exposed to high heat.

By applying basic knowledge of polymer chemistry to the problem of service life under heat, Monsanto is making new breakthroughs on the problem of high-heat resistance with plastics. One of the most promising plastics now being evaluated is a silane-modified phenol-formaldehyde resin which makes laminates and moldings that retain integrity after hundreds of hours of exposure to temperatures of 500-600° F. Still other polymers under development hold promise of broadening temperature resistance for increasing lengths of time.

MOLECULAR DISSOCIATION SETS UP COOLING ACTION

Some resins under study form a char layer which insulates the interior and reradiates a large portion of frictional energy. Plastics laminates made from such resins provide insulating walls for interior surfaces or areas.

HEAT RESISTANCE—PLUS STRENGTH AND LIGHT WEIGHT

As in many other fields, laboratory tests for space-vehicle science are hard to correlate with actual field performance. In standard Oxyacetylene Tests and Stabilized-Arc Tests, heat-resistant plastics laminates show adequate retention of structural integrity under high-heat stress.

Like other, more common reinforced plastics, the new heat-resistant laminates have exceptional mechanical strength. The following table indicates some of the mechanical properties obtained with a ⅛" section of a laminate made with a Monsanto silane-modified phenol-formaldehyde resin.

Property	Results	MIL-R-9299 Specifications
Flexural Flatwise		
Standard Condition 75° F.	73,800 psi	50,000
30-Day Water Immersion	73,400 psi	45,000
½ hr. @ 500° F.	62,900 psi	40,000
100 hrs. @ 500° F.	57,600 psi	20,000
200 hrs. @ 600° F.	22,600 psi	No Spec.
Modulus of Elasticity		
Standard Condition 75° F.	3.72×10^6	3.0×10^6
30-Day Water Immersion	3.65×10^6	3.65×10^6
100 hrs. @ 500° F.	3.28×10^6	2.5×10^6
200 hrs. @ 600° F.	1.48×10^6	No Spec.
Tensile Strength		
Standard Condition 75° F.	45,600 psi	40,000
30-Day Water Immersion	45,400 psi	38,000
100 hrs. @ 600° F.	23,100 psi	No Spec.
Edgewise Compression		
Standard Condition 75° F.	50,800 psi	35,000
30-Day Water Immersion	42,000 psi	30,000
100 hrs. @ 600° F.	8,240 psi	No Spec.
Barcol Hardness	76	55
Flammability	Self-extinguishing	1.0 max.

Mechanical Properties of Resinox® SC-1013 Laminates. (⅛" section; E.C.D. 225-181 glass cloth; 12 ply; 200-psi pressure cured 1 hr. at 250° F.; post cured in gradients of 50° F./24 hrs. each to 500° F.; resin content 29%)
(Tests carried out as specified by MIL-R-9299)

COMMERCIAL PROMISE, TOO!

In addition to the properties described, the plastics laminates created for high-heat resistance are practically immune to fuels, oils, and solvents.

(Please turn page)

OUTSTANDING ELECTRICAL PROPERTIES

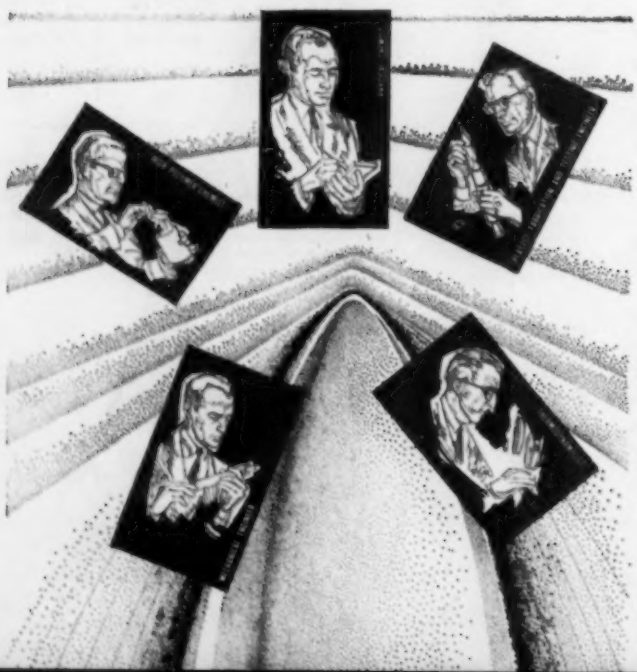
Heat-resistant plastics laminates have also shown outstanding performance in electronic applications wherever frequent cycles of heat and cold are a problem. While maintaining mechanical strength, plastics laminates (as described) showed no degradation of dielectric constant or loss tangent. The following table shows results on a typical panel after various numbers of cycles of heating for one hour at 550° F., then cooling ¼ hour to room temperature.

ELECTRICAL PROPERTIES AFTER CYCLING
(Approximately 9 KMC Resonant Cavity)

	Room-Temperature Electrical Properties	
No. of Cycles (1 hr. at 550° F.; ¼ hr. to 77° F.)	Dielectric Constant	Loss Tangent
0	4.8007	0.0217
100	4.7289	0.0218
150	4.7347	0.0218
200	4.7218	0.0214

OPTIMUM PARTS PERFORMANCE

In fabricating parts for optimum performance under high-heat conditions—fibrous glass, asbestos, or nylon is impregnated with resin, is molded, filament-wound or laminated by any of several methods, then cured.



THE CONTINUING SEARCH

Project "Heat Foil" is a continuing study of resins for high-heat resistance and of resins whose energy of dissociation makes them outstanding for high-temperature applications. This search will continue to develop materials that will help answer the high-heat requirements of a space age, in defense and industry. MONSANTO CHEMICAL COMPANY, Department MR-5, C Building, St. Louis 66, Missouri.

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* Coolant-Dielectrics for Electronic Equipment
* High-Temperature Plastics
* Improved Nitrogen Oxidizers for Solid Propellants
* Fire-Resistant Structural Plastics
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* Fire-Resistant Hydraulic Fluids for Ground-Support and Missile-Launching Equipment
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THE MISSILE / SPACE WEEKLY

missiles and rockets

Volume 8, Number 22 May 29, 1961

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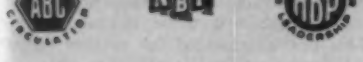

THE COVER

M/R artist's conception symbolizes U.S. effort to get manned spacecraft to the moon and planets. The effort is plagued by problems. See special report starting on p. 32.

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† U.S. Reg. Pdg.

36,645 copies this issue

letters

Further on MR-3 Publicity

To the Editor:

I think the views you have expressed in the May 8 and May 15 editorials on the Man-in-Space program are the feelings of many who are connected with the missile industry, not only the Man-in-Space Program.

The publicity that has been given to the Man-in-Space program was vividly brought to my attention recently when I visited my 3-year-old nephew. His version of the program is as follows:

Silent night, Holy night,
All is calm, All is bright,
Shepard's in Space.

Charley Mathay
Development Engineer
Tapco Group,
Thompson Ramo Wooldridge Inc.
Cleveland

To the Editor:

I am appalled at your editorial, which too neatly subscribes to our Administration's program toward the U.S. citizen's ignorance of space.

The attitudes shown in M/R, May 8, are:

Page	Article	M/R	Admin.
7	"No News . . ."	Shout	Shut-up
54	"Editorial"	Shut-up	Shout

True, a problem is evident in space public relations; the U.S. press, radio, and television did "circus-up" the event in their everyday grab for an audience.

But please remember: 1) we are in a public opinion space race, 2) the free public feels that *Mercury* is their honor and prestige, 3) the per capita price of Freedom 7 ($2.25) *is* the ticket price of an extravaganza movie, 4) the *Redstone* vehicle is quite reliable, 5) McDonnell's fine staff have been paid to *over-engineer* the capsule, 6) the only capsules "lost" had *no* escape system, though the sensors and relays activated wildly to abort, and 7) by publicizing all attempts, we display to the free world and neutral nations our active truthfulness and honesty in the most evident manner—as we have also done with *Vanguard*, the U-2, and Cuba.

I wholeheartedly agree that our news media need many lessons in tasteful reporting and that some of the *Mercury* coverage was "nauseous" and "inane." But no matter how appealing the Soviet "news-as-history" approach may be; for any "space birthday party" in the U.S., the cake must be cut and served *at* the party—not packaged and mailed the next day as a feast for fungi and insects.

Whether our next attempt is a fiasco, partial success, or complete achievement, let us not play "guess-which-hand-the-marble-is-in."

Jamison D. Welsh
Co-op Student, Space Systems Intelligence
Astronautics Div.
Chance Vought Corp.
Dallas

To the Editor:

When I finished my 37 months as Director of Guided Missiles in 1953, I decided that I would refrain from any public comment in the field, because once you are out of direct contact with an endeavor, you are not so well equipped to be either a critic or an appraiser.

However, on reading the May 15 M/R, I am impelled to compliment you on the splendid editorial. I have also read, with considerable interest, the *Redstone* article by James Baar.

I think there is one thing that is usually overlooked in comparing the *Redstone* to the *V-2*. The *Redstone* had a stable platform that made it possible to employ a much more reliable guidance than any of the *V-2's* had. It also had the benefit of more years of development on propulsion. I quite well remember the days in early 1951, when Wernher von Braun made a splendid presentation of his plans for the *Redstone*.

We gave his ideas a very thorough going over. It was a very small meeting; I had five members of my staff with me. As we drew near the close of the meeting General Terhune of the Air Force (then Colonel Terhune) passed a note to me which said, "Mr. Keller, you and Wernher von Braun have just given birth to a missile!"

It is interesting to analyze the tremendous progress that has been made these last ten years. The propulsion motor is developing at least twice the thrust that it had in 1951, and the special work of the atomic energy boys has produced a warhead of equal destruction of about one quarter or less of the weight that we had to figure on in 1951. Both of these things have greatly increased the range of the *Redstone*.

I am just writing this in the interest of fact and clarity, and hope it will be of interest.

K. T. Keller
Detroit

Dean Space Drive

To the Editor:

The article by Charles D. LaFond on the Dean System Space Drive (M/R, May 1, p. 24) was particularly interesting to me because several years ago I had an exciting "ride" in Long Island, N.Y., on a similar device being developed by Assen Jordanoff. Jordanoff's centrifugal force converter was beyond the status of just proving a principle. I helped him measure output vs. input to get the efficiency. The 500-lb. man-carrying vehicle attained a speed of ⅓ mph. The sheer novelty of the concept intrigued me then and still does.

Alfred Africano
Rendondo Beach, Calif.

To the Editor:

Re your article on Dean's Space Drive, must have Dean's address immediately. Your cooperation deeply appreciated.

Over 20 years ago I devised, on paper, an anti-gravity method based on displaced inertial masses, and was discouraged by financial conditions from experimenting with it. However, I did take it to the chief of engineering and design at Douglas Aircraft, where I was then employed, and to the head of the Physics Department at U.C.L.A., where I had recently obtained my Master's Degree.

The peculiar results, in both cases, were exactly these:

1. Initially—derision.
2. After some investigation, the independent conclusion of both men was as follows:

Seems impractical, but no way of disproving it. There is *no mathematical basis* for measuring this new principle. Therefore, it must be proved experimentally.

My method seems to provide the missing link for Dean's system, in that it cuts out a great deal of gearing and throws many of the mechanical processes into the realm of electronics, thereby saving space and weight. A hint of its nature is in the name I have given it: the planetary rotor (in which inertial masses orbit *free*, like a true planetary system). Remember, Nature made all the discoveries before we did. I am only copying Nature.

My object with Dean: I have given up on the financial end. My idea may be worthless, or it may be a bottleneck-buster. I am willing to place myself completely at Dean's mercy, as I feel he will get somewhere. What he wants to do about my contribution, if it's worth anything, is up to him. However, I'd like to give him my concept.

I am an engineering writer in the missile field.

S. J. Byrne
B.A., M.A.
Van Nuys, Calif.

For the benefit of Mr. Byrne, and others who may be interested, the address is:

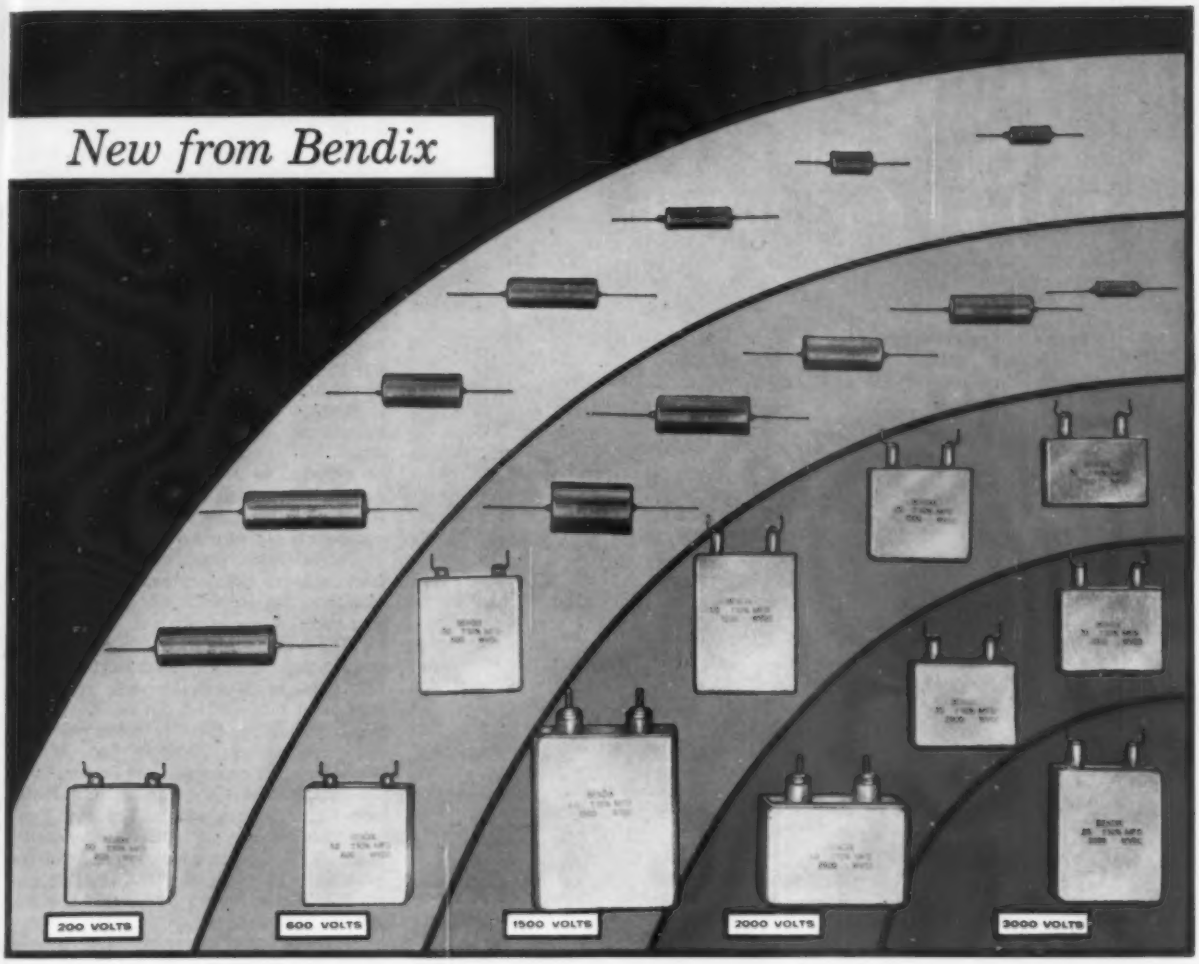
Mr. Norman L. Dean
3601 Wisconsin Ave., NW
Washington, D.C.

More on Wire & Cable

To the Editor:

In your March 27 issue was a "Study in Near-Chaos" by Mr. Hal Gettings together with a Special Report by Mr. Edward W. MacLaren regarding wire and cable problems in the missile industry. We generally agree with most of the statements made in these articles, but we are highly concerned about the accuracy of Mr. MacLaren's statement regarding a $3 million cost per site of missile ground-cable systems—and "in some instances as much as $10 million."

Several years ago, as one of the Composition F approved sources for MIL-C-13777 cable, we had made a market study of the requirements for this cable. Initially this study produced essentially the same figure quoted by Mr. MacLaren. However, believing this to be an exaggerated reporting, we made a more intensive survey. This re-evaluation of the market brought



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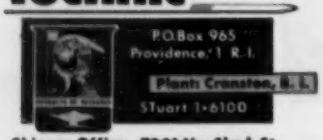

Chicago Office: 7001 No. Clark St.

us to the conclusion (which I think is shared by others in the cable business) that the original figure was highly inaccurate, and our own plans were made on what we felt to be a more realistic basis.

We would, however, be interested in knowing the basis for Mr. MacLaren's estimate of the scope of this market, and we would certainly appreciate any information you can give us on this subject.

Charles R. Riordan
General Sales Manager
William Brand-Rex Division
American Enka Corporation
Concord, Mass.

To the Editor:

The statement in the 7th paragraph of the article entitled "Standardization 'Engineering' Is an Urgently Needed Development" is overly generalized and grossly misleading in that there is an implication that from $3-10 million of ground *missile cable* is used for each missile site. Clarification of the statement by the author is requested and considered necessary.

The electrical system of a missile site utilizes wire and cable types of three broad categories, namely:

A. Wire and cable for light, heat, power, air conditioning, and control wiring for "brick and mortar" silo, and for housing.

B. Telephone and data transmission cables for inter-site and intra-site communications.

C. *Missile wire and cable* directly associated with the missile installation site to provide power and circuits for monitoring and control of the missile proper.

The cost estimate of $3-10 million per site is not plausible when applied as a per-site cost of *ground missile* cable (Category C cable).

A "missile site," depending on definition, can consist of one isolated missile firing site or "hole," or a group of sites forming a complex or a group of complexes. The cost of the missile ground system would obviously vary with "site" definition.

Additionally, sites can be of the operational or R&D type. For many reasons, the cable system for an R&D-type site may be of far greater complexity and require considerably more cable than an operational site.

Regardless of other factors which may have been considered by the author in arriving at the $3-10 million cost estimate, it would appear that the cost of cable per site and particularly the cost of missile cable (Category C as defined above) generally represents only a small percentage of the dollars quoted in the article. We believe that an editorial correction is in order.

T. DeLutis
Product Manager, Missile Cables
General Cable Corporation
New York

The author agrees that the "per site" cost definition as stated is open to misinterpretation. "Complex" might perhaps be a better word. In any case, accurate data on the missile W&C market is extremely difficult to determine (as most market researchers will quickly agree). Part of the problem is the lack of hard-and-fast functional discrimination between different types. Mr. MacLaren's figures included communication and support cable—which account for the bulk of installation costs. Also see the following letter.—Ed.

To the Editor:

In your wire and cable report was a statement that "It is no longer uncommon for a guided missile ground cable system to cost more than $3 million per site—in some cases as much as $10 million."

Since the scope of your special report was concerned mainly with missile and ground support cable (MIL-C-13777, etc.), it's quite possible that many of your readers may assume that the above dollar figures pertain to this type of cable. On this basis, and if the word "site" were used to mean a single missile pad, the *Minuteman* base at Malmstrom AFB, Mont., which will contain 150 missile sites, could be expected to have between $450 million and $1.5 billion in missile and GSE cable. Available figures would show this to be completely out of reason.

Actually, the amount of ground support cable per *Minuteman* missile is so far less than, for instance, an *Atlas-A* system that there is no comparison.

There is confusion in the Industry on missile terminology (squadron, base, complex, site, etc.) and the same words are even used differently from missile to missile. In addition, there is confusion about the various types of cables used. A given *Titan* base, for example, uses Power Cable, Communication Cable and Ground Support Cable, among others. The term "missile cable" is commonly used to denote the latter. It is often erroneously used to cover practically any type of wire and cable used by the Missile Industry, and this is where the confusion starts.

Perhaps your magazine could help to clarify the situation.

Bruce Van Wagner
Marketing Manager
Anaconda Wire and Cable
New York

Administrative Awareness

To the Editor:

Your March 6 editorial ("Let's Not Hang an Untried Man") was vague, but I could see your point clearly. The practice of placing administrative department heads in highly technical fields is widely practical and wise. The Air Force is probably the initiator of this, with its retraining program. President Kennedy's move was brilliant; and if you look a little more closely, all of his Cabinet is assigned on the basis of proven administrative awareness. Definitely, the choice was made to avoid duplication and waste of research and money. This, I believe, is why the slot was filled by Mr. Webb.

I can agree that the practice can always be discussed, with many pros and cons on both sides; but—speaking bluntly—with 40 to 100 missile programs advancing torridly, it was more a matter of need than of choice.

I am no relation to Mr. Webb.

Bernard J. Webb
926th ACWRON Box 143
Baffin Island, Canada

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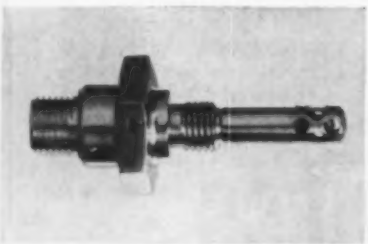

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VHF-UHF TRANSMITTERS

Proved in history's most demanding environmental laboratory — outer space — the custom designed unit shown above is typical of the development skill and production capability available from Microdot. The unit shown in miniaturized, pressurized, and features a solid state power supply that cannot be damaged by input/output overloads. Units are available in a complete range of modulation — CW, FM, Phase, and Pulse, with frequency coverage 100 to 5000 mc/s and output from 100 mw to 10 watts.

Telemetry Capabilities at Microdot have been dramatically expanded with the recent acquisition of Spectralab Instrument Company. The highly regarded development skill, production capability, and working experience of Spectralab in the field of VHF and UHF cavities and related instrumentation is available from Microdot's Instrumentation Division. This equipment, outstanding in its attention to miniaturization and ruggedness, is a vital part of such important projects as Pioneer V, Jupiter, Atlas, Pershing, Redstone and Echo I.

UHF Telemetry Transmitters, Models 2406 and 2409, use a unique, automatically stabilized circuit, with the output frequency referenced directly to a quartz crystal. This approach allows a greatly reduced size compared to the multiplier chain conventionally required to achieve crystal stability, as well as increased reliability due to a fewer number of parts.

The transmitters have their own solid state power supply designed to provide a high ratio of rf output power to total power input. The frequency modulation circuitry is sufficiently linear to introduce completely negligible distortion to the modulation signal. For further information, Call Microdot or write for catalog sheet TT-1.

SPECIFICATIONS

Frequency Range:	
Model 2406	2200-2300 mc/s
Model 2409	1435-1535 mc/s
Frequency Stability:	±0.001%
Power Output:	10 watts
Power Output Stability:	1 db
Modulation:	PCM/FM, PAM/FM, FM/FM
Input Voltage:	28 vdc
Temperature Range:	−40°C to +70°C
Vibration:	10 g, 5-2000 cps
Size:	3⅜" x 7¾" x 11"
Weight:	12 pounds

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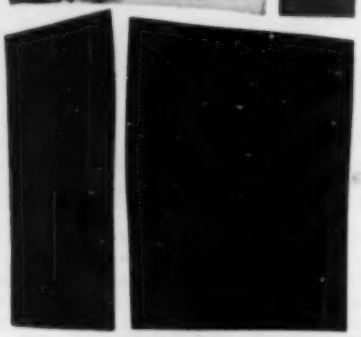

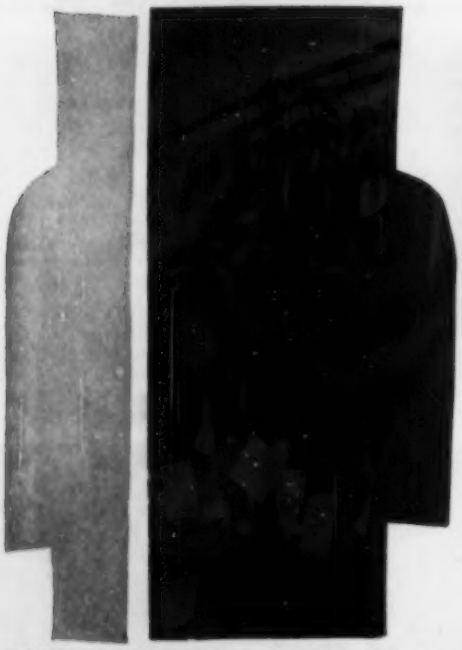

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The Countdown

WASHINGTON

Mobile Minuteman—Stretchout to Where?

All planned further R&D work on a mobile *Minuteman* in FY '62 will be financed out of funds salvaged from the $110 million set aside for developing the system in FY '61. This means tests with two or three railroad cars nearing completion—not five as originally planned. However, there is no Administration commitment that the mobile system ever will be deployed.

Fixed Minuteman—Buildup to What?

President Kennedy has about six months to decide whether to order a great increase in the total size of the hardened *Minuteman* force. About Dec. 1 is the deadline for taking full advantage of $36 million the Administration has requested to double *Minuteman* production capacity. After that, the value of the extra production capacity will begin to decline. So far the Administration has not increased the total planned *Minuteman* force, only accelerated deployment.

Abe Lincoln Launches Five of an Afternoon

The nuclear-powered submarine Abraham Lincoln, operating under DOD-imposed secrecy, is understood to have launched five operational *Polarises* down the Atlantic Missile Range in one afternoon earlier this month. She is understood to have sailed with a full load of 16. According to a Cape report, holds prevented the planned launching of more birds the same day. But the report is unconfirmed.

Gen. White's Druthers

The three top items on the Air Force suggestion list for restoration to the FY '62 budget are: More R&D for B-70 ($138 million); deployment of two more *Titan II* squadrons (about $100 million); more R&D for mobile *Minuteman*. Under the revised FY '62 budget, the Air Force says, the mobile *Minuteman* program is slipping about two years or more.

MA-3 Repeat Slips

NASA and Convair are still attempting to discover the cause of last month's *Mercury Atlas-3* failure to orbit an unmanned capsule. Hence, no date has been set for a repeat.

INDUSTRY

Thor: Shot in the Arm

Production of *Thors* by Douglas Aircraft is being extended through June 1962 by an Air Force order for 22 *DM-21* models to be used in space programs. The *DM-21* has a shorter, lighter airframe and develops 165,000 lbs. thrust. Douglas, in a bid for more space work, also is proposing to cluster three *Little Joes* (50,000 lbs. thrust each) at the base of *Thor* to increase total boost thrust to 315,000 lbs.

R&D Intelligence

AT&T is understood to be asking NASA for permission to buy a *Thor-Delta* to use in launching its first R&D commercial communications satellite. . . . Aerojet-General is set to fire a 100-in. segmented solid engine in an effort to hit 1 million lbs. thrust. . . . Mystery surrounds future plans for the *Titan* Silo Launch Test Facility at Vandenberg AFB. Since the first shot May 3 with a *Titan I*, the silo has been partially stripped and no announcements have been forthcoming on launching *Titan II's* or other vehicles from it.

On the Static Test Pad

"By the book" evaluation of both stages of *Titan I* will begin at Edwards AFB Rocket Test Agency following some stand modifications. . . . *Centaur* firings will start there within a few weeks.

Front Offices

Dr. James B. Rea is moving from Hughes Aircraft Co. to vice president and general manager-technical of Northrop Corp.'s Radioplane Division. Move is reported to be the first in a mild reorganization of Radioplane, to be followed by recruiting in the high-level technical staff. . . . RCA is staging a recruitment campaign for electronic engineers to go to the South Pacific for high-powered radar and radio work—possibly for Project *Press*.

INTERNATIONAL

British BMEWS Slips Six Months

Labor disputes involving only 30 spidermen who install steelwork have put the operational date for the British BMEWS Station six months behind the original target date of late 1962. British officials are reported to have refused to crash the job to make up for lost time. They contend that this would increase cost and jeopardize accuracy. The British station on Fylingdales Moor in Yorkshire is the third and last of the BMEWS net.

Data on French Missiles Disclosed

Latest facts on two ONERA research rockets: *Antares* —a four-stage solid capable of Mach 8 re-entry. Six successful launchings completed in last few months. *Berenice* —an improved *Antares* capable of Mach 12 re-entry. First launchings scheduled before the end of the year.

First Indian Transistor Plant Readied

Facilities for India's first transistor plant are under construction at Poona. The new company—Semiconductors Private, Ltd.—is expected to be turning out transistors and diodes by late 1961. Raytheon owns a one-third interest. Participants with Raytheon are Indersen Mirchandani and Taru Lalvani, prominent Indian businessmen.

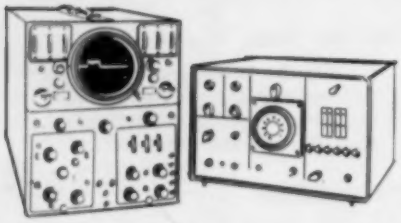
Overseas Pipeline

A public demonstration of the Vickers Armstrong *Vigilant* antitank missile is tentatively expected next month. . . . A major technical advance in underwater sound detection is reported to have been made at the NATO Research Center at Spezia, Italy. . . . The Japanese are launching a big drive to sell space research rockets in the world market. . . . Goonhilly Downs, in Cornwall, has been chosen as the site for an Anglo-American $1.5-million communications satellite ground station.

SPACE AGE PRODUCTS

by DU MONT of FAIRCHILD

INSTRUMENTATION FOR THE SPACE AGE



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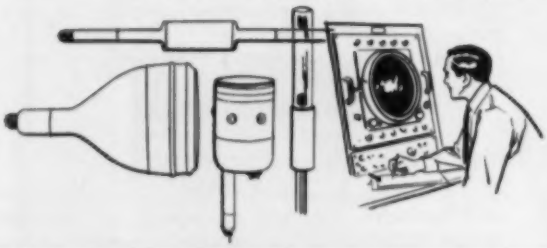
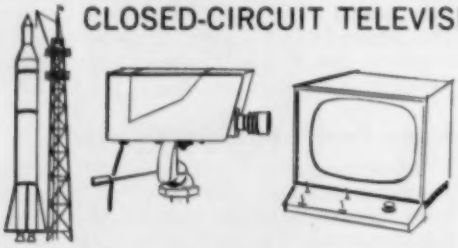
TUBES FOR THE SPACE AGE



Du Mont direct-view storage tubes, multiplier phototubes, special and standard cathode-ray tubes, scan converters and many special types of tubes are presently used in radar, computers, scopes and advanced systems installations and projects—military and commercial. Check Du Mont first for the best in display, storage and conversion components—standard or specialized. Du Mont offers the *greatest capability and variety* of special cathode-ray tubes and multiplier phototubes—almost 2,000 different types—from miniature ⅞-inch diameter CRT's to giant 30-inch diameter display tubes.

CLOSED-CIRCUIT TELEVISION FOR THE SPACE AGE



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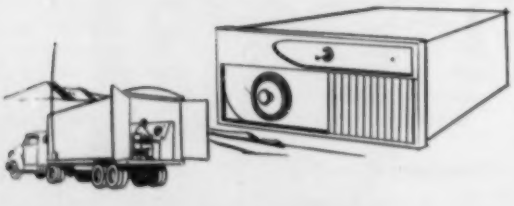

The Du Mont Transicom, the newest development in commercial, low-cost 2-way radio receiver/transmitters, is available to satisfy business, industrial, or military and missile base requirements. Compact, under-the-dash mounting on any vehicle, or for mounting snugly in the trunk or special compartment. Du Mont also manufactures all types of base-stations, portable transmitter/receivers, transistorized frequency meters, dial-direct systems, and other rugged, high-quality equipment for headquarters to vehicle communications.

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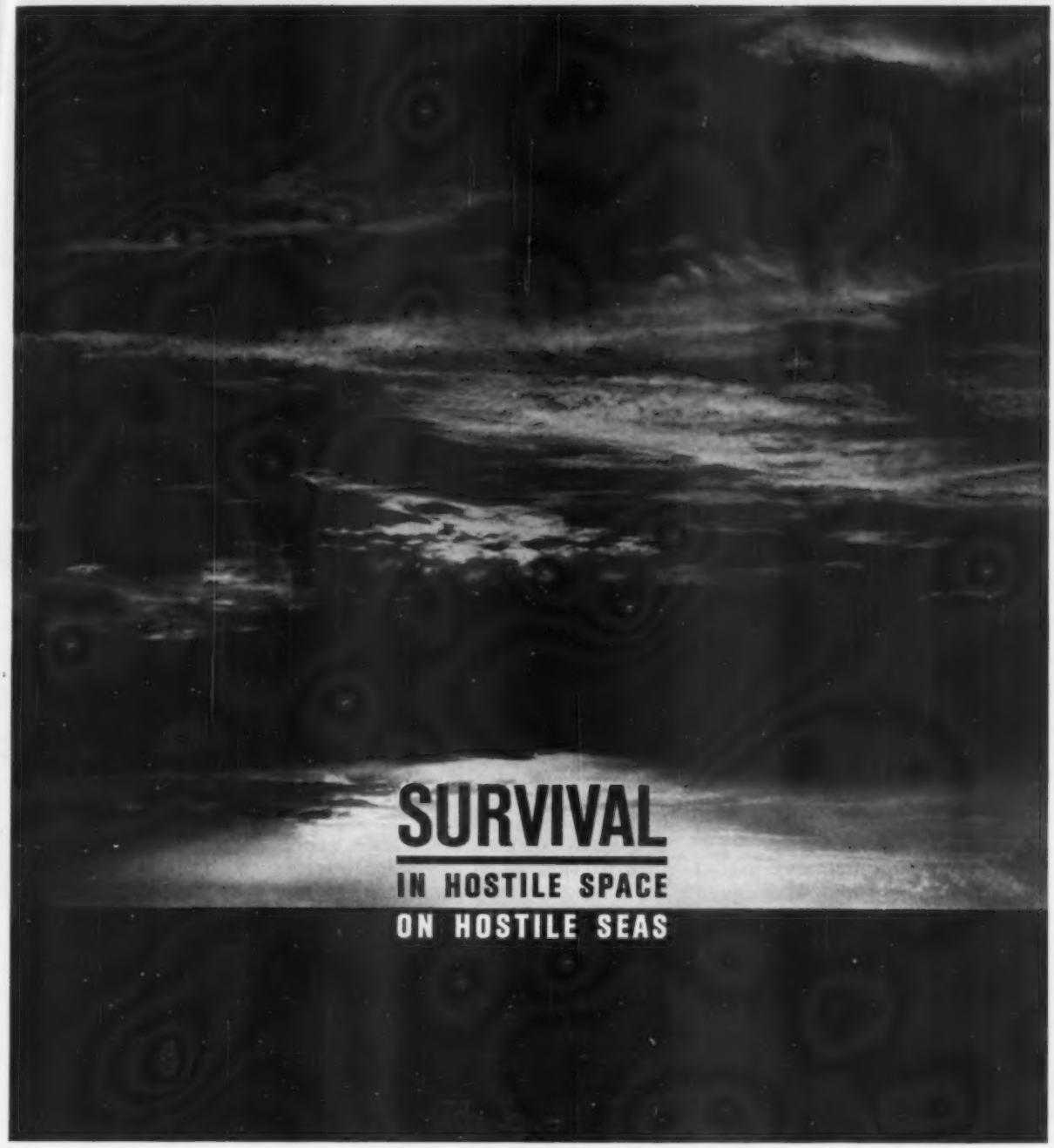

For more than 18 years man's survival in hostile environments has been a major concern of International Latex Corporation. In times of war—beginning with WW II—ILC flotation equipment and protective clothing have saved the lives of countless sailors and airmen. Underwater lift floats for raising mines, life boats and rafts, helmets for tank crewmen, firefighter suits—these are some of the ILC products which have protected men against the hazards of war.

Now—from a world at dubious peace—man launches himself into the hostile vastnesses of space. Among the strange new perils threatening his survival are radiation, lack of atmosphere, weightlessness. Working for 6 years with the Air Force Wright Air Development Division, International Latex Corporation has recently perfected the first space suit to combine "shirt sleeve" flexibility with protection. It weighs about 20 pounds, can be quickly put on by the wearer, allows pressurization to at least 5 psi.

This ILC space suit—actually a portable environmental system—is only one breakthrough in International Latex Corporation's continuing development program. In the life sciences we are now considering, among others, the essential problems of weightlessness and of thermal, particle and electro-magnetic radiation—further steps in our constant effort to serve mankind by enabling him to survive in a hostile environment.

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The Missile/Space Week

Dyna-Soar Work Let

Four contracts totaling $9 million were let this week by Boeing Co. for components of *Dyna-Soar* integrated hydrogen power and cooling system.

Sundstrand Aviation-Denver has contracted to build an auxiliary power unit to drive the *Dyna-Soar* electrical generating system in flight.

Garrett Corp. won a major subcontract for R&D on *Dyna-Soar's* hydrogen cooling system, an important function in controlling the vehicle's environment.

Thompson Ramo Wooldridge Inc.'s Tapco Division will provide *Dyna-Soar's* reaction control power component.

A subcontract in excess of $1 million was awarded Westinghouse Electric for a 400-cycle, three-phase brushless generator and control unit for the winged vehicle.

RCA Gets Relay Contract

Radio Corp. of America will design and build the *Relay* active repeater communications satellite.

NASA's Goddard Space Flight Center, will negotiate a contract for about $3¼ million with RCA's Astro-Electronics Division to deliver four satellites—one prototype, two for flight and one spare.

The spacecraft, which will weigh between 85 and 100 lbs., are to be launched by *Delta* vehicles in 1962 from Cape Canaveral into orbits with perigee of about 1000 miles and apogee of about 3000 miles.

The British General Post Office and the French Center for Telecommunications Studies will provide ground stations in Europe for transmission of multi-channel telephone, telegraph and television signals.

RCA won out over seven other bidders or teams. The losers were Bell Telephone-Western Electric, International Telephone & Telegraph-General Electric, Collins Radio-Ford Aeronutronic, Philco, Bendix and Hughes Aircraft.

ABL Blast Probed

Authorities are still investigating a series of fires and explosions which rocked the Allegany Ballistics Laboratory's solid propellant division near Cumberland, Md., last week.

The blasts and fires caused nine deaths and injured six persons.

The initial explosion, which leveled one building, set off fires which in turn caused the explosion of another building some eight hours later. A third building was damaged.

Skybolt Slimmer, More Pointed

NEW SKYBOLT SHAPE is revealed at Armed Forces Day observances in Los Angeles. Elmer P. Wheaton (left), Douglas Vice President; Dr. Joseph V. Charyk (center), Undersecretary of the Air Force; and Donald W. Douglas, Jr., discuss details of the 1000-mile-range air-launched strategic missile.

Mercury Developments

At least two unmanned *Mercury Atlas* orbital launchings are planned this summer before an attempt is made at manned flight.

George M. Low, NASA chief of manned space flight, also told the Peaceful Uses of Space Conference, "if all goes well, the first manned orbital flight will be made before the end of 1961."

Meanwhile, other NASA sources reported that Astronaut Alan Shepard has recommended three minor changes for the next manned *Redstone* flight, which will probably take place in July.

Shepard suggested that the pressure gauge of the pressure suit, now on the astronaut's left wrist, be moved so that it will be more visible, that the astronaut be given more time for observation and that the time spent in the capsule atop the gantry be reduced.

Shepard on May 5 entered the *MR-3* capsule at T—80 min. but, because of subsequent holds, was in it for 3½ hours before liftoff.

Next Week . . .

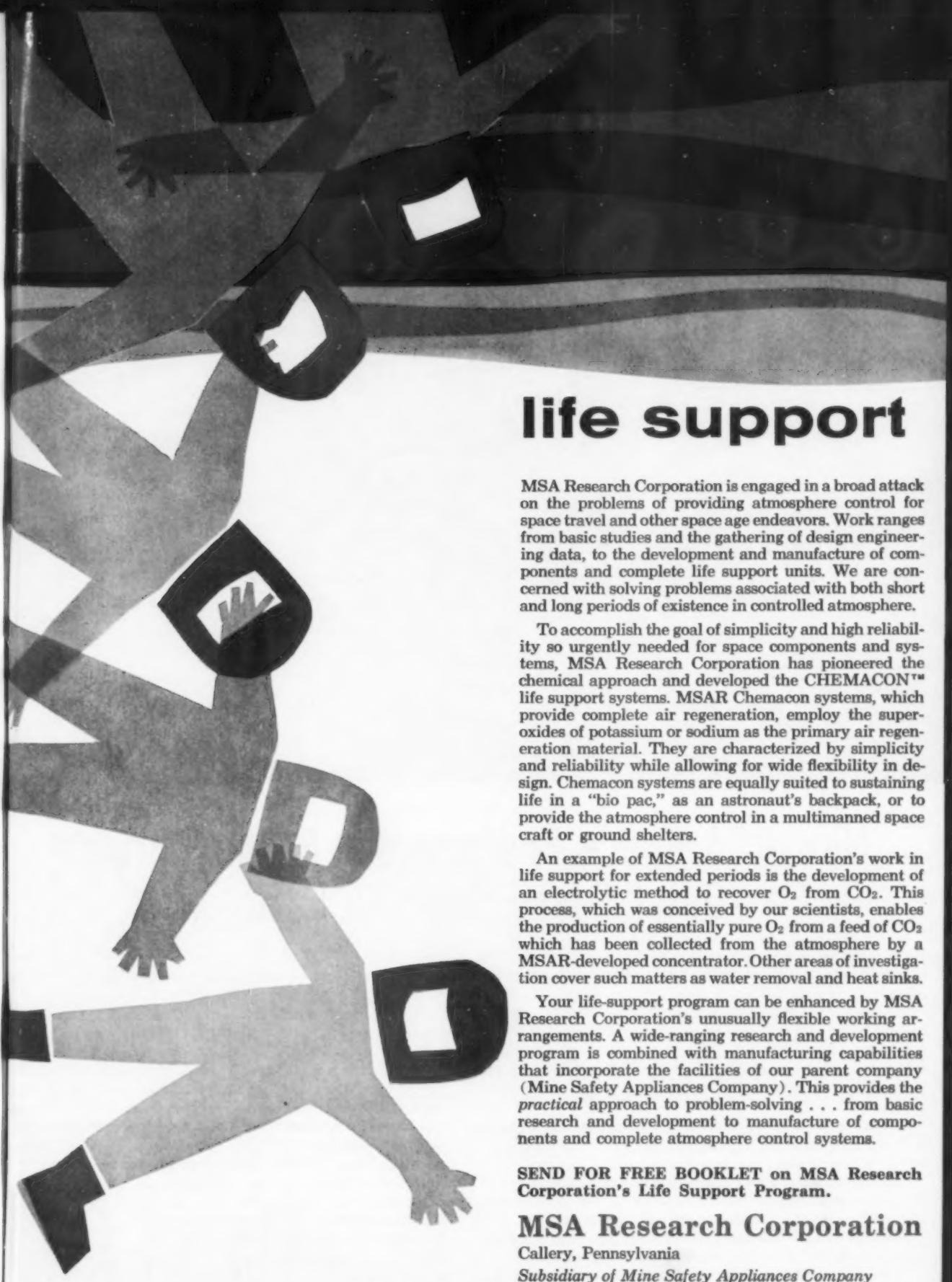
Missiles at Paris. In the June 5 issue of Missiles and Rockets there will be a special report on the Paris Air Show. An editorial team on-the-scene is ready to give full coverage to the missile/space activities at the show.

Shots of the Week:

The Air Force successfully fired an operational prototype *Titan I-J*, but had to destroy a *Minuteman* 90 seconds after liftoff on the ICBM's second flight.

The 24th success for *Titan* came in a flight May 24 which carried it 5000 nautical miles down the Atlan-

(Continued on page 18)



life support

MSA Research Corporation is engaged in a broad attack on the problems of providing atmosphere control for space travel and other space age endeavors. Work ranges from basic studies and the gathering of design engineering data, to the development and manufacture of components and complete life support units. We are concerned with solving problems associated with both short and long periods of existence in controlled atmosphere.

To accomplish the goal of simplicity and high reliability so urgently needed for space components and systems, MSA Research Corporation has pioneered the chemical approach and developed the CHEMACON™ life support systems. MSAR Chemacon systems, which provide complete air regeneration, employ the superoxides of potassium or sodium as the primary air regeneration material. They are characterized by simplicity and reliability while allowing for wide flexibility in design. Chemacon systems are equally suited to sustaining life in a "bio pac," as an astronaut's backpack, or to provide the atmosphere control in a multimanned space craft or ground shelters.

An example of MSA Research Corporation's work in life support for extended periods is the development of an electrolytic method to recover O_2 from CO_2. This process, which was conceived by our scientists, enables the production of essentially pure O_2 from a feed of CO_2 which has been collected from the atmosphere by a MSAR-developed concentrator. Other areas of investigation cover such matters as water removal and heat sinks.

Your life-support program can be enhanced by MSA Research Corporation's unusually flexible working arrangements. A wide-ranging research and development program is combined with manufacturing capabilities that incorporate the facilities of our parent company (Mine Safety Appliances Company). This provides the *practical* approach to problem-solving . . . from basic research and development to manufacture of components and complete atmosphere control systems.

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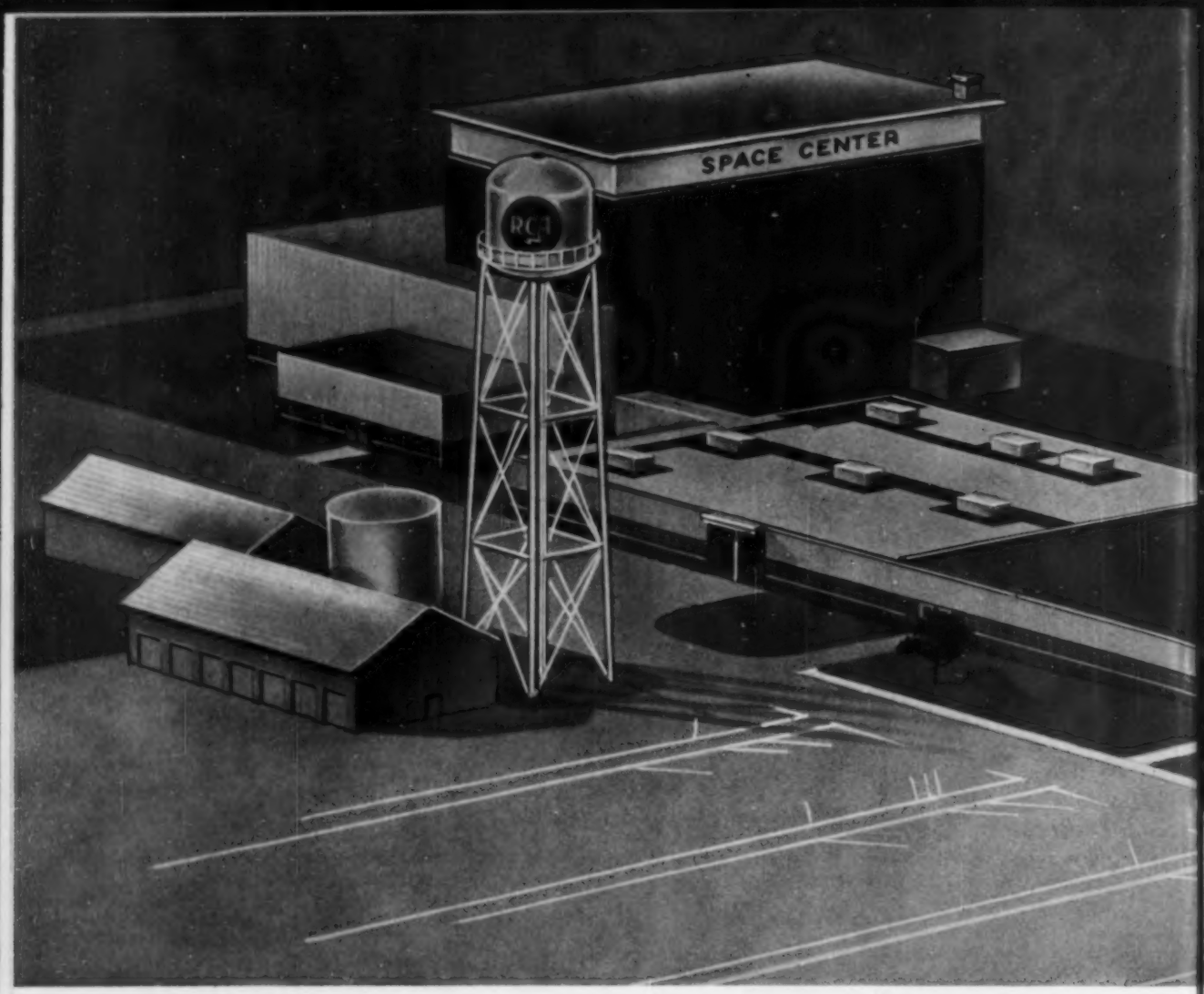

New RCA Space Environment Facility Brings Outer Space Down to Earth...

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RCA expands its proved capability to meet the challenges of space-age technology with the construction of an advanced space environment center at Princeton, N. J. Here, today's *and* tomorrow's space vehicles and satellites can undergo a new degree of intensive and thorough testing prior to "launch" to achieve greater reliability in space.

Included in the new environmental equipment and facilities being built and installed at the RCA Space Center are the following advanced testing devices:

Vacuum-Thermal Chamber—measuring 28 feet in diameter and 25 feet high to accommodate the coming generations of space vehicles and satellites and meet all vacuum-thermal requirements.

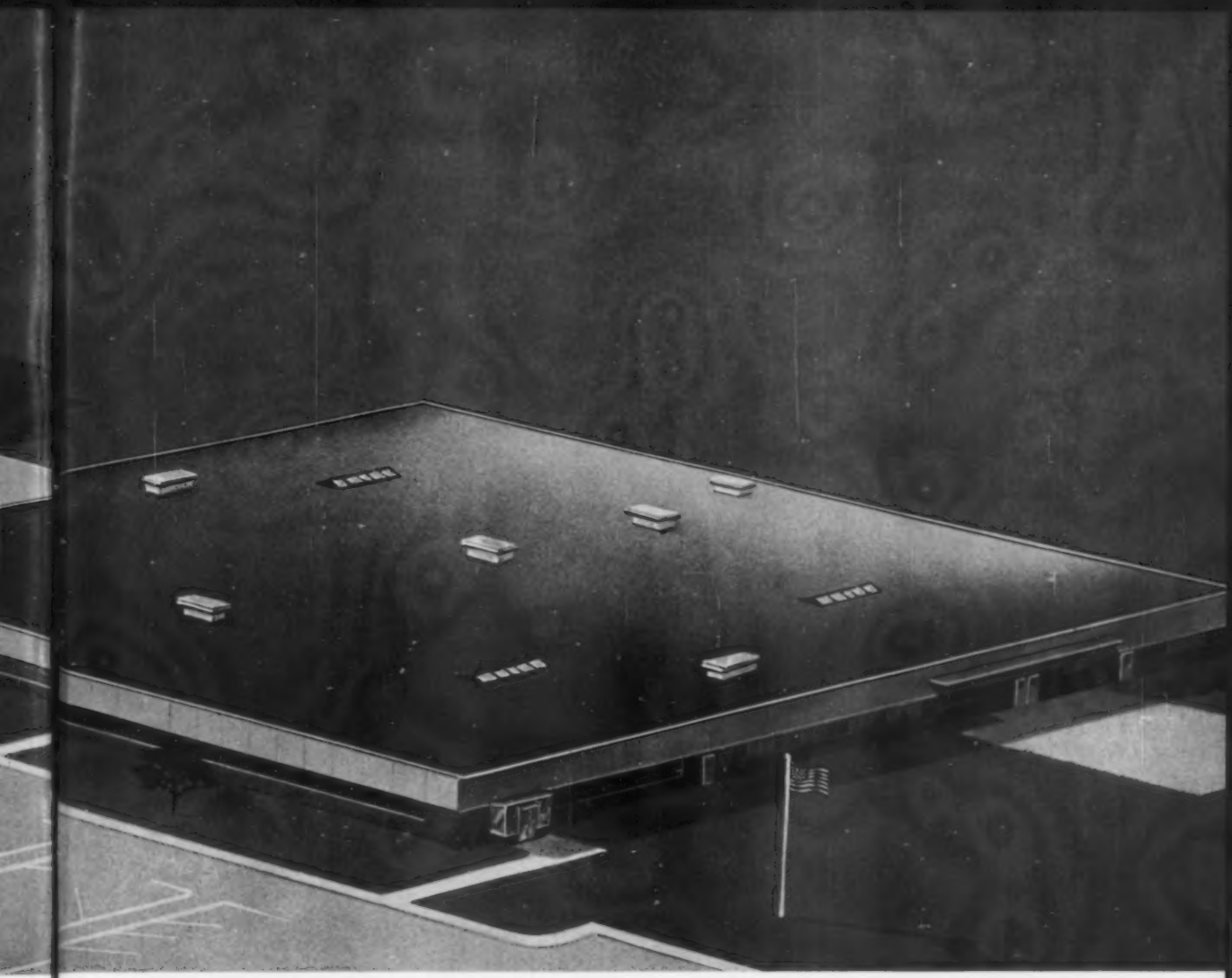
Vibration System—provides 28,000 pounds peak force for sinusoidal, and 28,000-pound rms force for random motion testing.

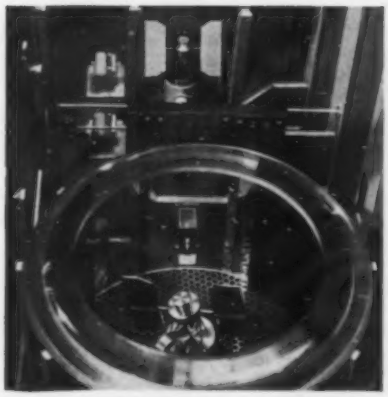
Temperature-Humidity Chamber—so versatile it can create virtually any thermal-humidity condition desired. Temperatures may be varied from —50° F to 250° F; humidity from nil to maximum

Rotary Accelerator—subjects subsystems of space vehicles and satellites to forces as high as 2500 g lbs.

The entire RCA Space Center, which contributed to the success of projects such as SCORE, TIROS I, TIROS II and ECHO I, continues to be dedicated to the conception, development and production of earth satellites, space vehicles and ground support and information handling equipment. For additional information about RCA's engineering talents and proved capabilities, contact the Manager, Marketing, RCA Space Center, Box 800, Princeton, N. J. And, for a complete description of the new environmental facilities, write for your copy of the brochure "RCA Space Environment Center."

If you are interested in participating in the challenging opportunities that exist at the RCA Space Center, contact the Employment Manager, Astro-Electronics Division, Defense Electronic Products, Princeton, N. J. All qualified applicants are considered regardless of race, creed, color or national origin.





New advanced Vacuum-Thermal facility shown in model has pumping system that can reduce pressure to 5 x 10^{-6} mm Hg within 24 hours with a 3500-pound payload in the enclosure.

New Vibration System will include 28,000-pound exciter driven by an amplifier capable of delivering 140 KW over a frequency range of 25 to 10,000 cps.

All existing environmental equipment will be housed here and a new high-bay assembly area provides facilities for assembly of an increased number of space systems.

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tic Missile Range. There have been seven partials and four completely unsuccessful shots in the program.

Instrumentation data showed the *Minuteman* was going well after second-stage ignition on May 19 when it suddenly veered off course. The destruct was not visible to observers at Cape Canaveral. The bird was programed for a 4600-mile flight.

The Army's *Redstone* satisfied all test objectives on a 200-mile jaunt down the AMR on May 17.

Juno II's Swan Song

In the last attempt to launch a *Juno II* satellite—the ionosphere beacon *S-45*—the upper stages apparently failed to fire May 24.

It was the second attempt to launch the 75-lb. NASA satellite. On the first attempt Feb. 24, the upper stages also failed to fire.

Juno II closed out its books with a record of three successful launchings, five failures and one partial success *(Pioneer III)*.

LeMay Will Add Toughness

The nomination of Gen. Curtis LeMay as the new Air Force Chief of Staff will put at the head of the Air Force one of the nation's toughest military men.

The blunt, 54-year-old Vice Chief of Staff and former SAC commander in chief, will succeed Gen. Thomas White on June 30.

Gen. Frederick Smith, Jr., 53-year-old commander of USAF in Europe and the Fourth Allied Tactical Air Force, was nominated to succeed LeMay as Vice Chief of Staff.

Appointment of LeMay is expected to result in powerful new emphasis on the development of advanced manned aerospace craft, as well as a greater build-up of strategic forces in being.

Tracking Advent at Sea

The shipboard tracking link of the Army *Advent* instantaneous radio communications system will be provided by Bendix Corp. under a $670,000 contract.

Advent will remain over a fixed point at the equator by orbiting the earth at an altitude of 19,300 miles with a 24-hour period.

GE Ordnance Department will develop the antenna for the seaboard terminal. The antenna device will have a three-axis drive to permit uninterrupted satellite tracking despite pitch and roll motion of the ship.

The two shore stations for *Advent* will be at Fort Dix, N.J., and Camp Roberts, Calif.

Soviet Academy Downgraded?

The recent resignation of the Soviet science chief may be part of the shakeup which has put all Soviet research under a military-dominated "supercommittee" (M/R, April 24, p. 34).

Alexander N. Nesmeyanov, 62, vacated his post "at his own request" after being president of the Soviet Academy of Sciences since 1951. He directed the space program which led to the orbit and return of Yuri Gagarin April 12.

The Academy's position as leader of Soviet research has apparently been downgraded with the new emphasis on practical application of research.

New president of the Academy is Matislav V. Keldysh, 50-year old mathematician and expert in mechanics and computing techniques.

Word From Explorer, Tiros

Explorer XI, the gamma-ray astronomy satellite launched April 27, is giving good telemetry on direct readout, but the tape-recorded data is reported to be poor in quality.

Research and Engineering for

MAN IN SPACE

The feature section of this special issue starts on page 32.

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The satellite's orbit, which reaches an apogee of 1111 miles, brings it into the lower Van Allen belt for a good part of the time and the Van Allen radiation limits its usefulness near apogee. The best telemetry comes when the perigee is near a direct readout station.

The satellite has begun the tumbling motion necessary for a complete scan of the sky. The change to the tumbling motion required about three weeks from launch.

Tiros II, in orbit six months, is still transmitting. The narrow-angle television camera has been operating perfectly since launching last Nov. 23, NASA reports.

Infrared data is still being received. But for the last month the quality of the IR signal has been poor, apparently because of low voltage.

Echo II Design Verified

The G. T. Schjeldahl Co. has completed the first inflation tests of the 135-ft. rigidized *Echo II* balloon satellite.

The tests took place in the same hangar used to test the *Echo I* balloon at Schjeldahl's Northfield, Minn., plant before it was launched last year.

Echo II consists of a three-ply laminate made of .20 mil aluminum foil bonded to Mylar plastic .35 mil thick. Weighing 500 lbs., the balloon folds into a 40-in. spherical metal container.

By contrast, *Echo I* was only two layers, Mylar inside and aluminum outside, with total thickness of .55 mil, and only 100 ft. in diameter. The *Echo I* balloon, weighing 135 lbs., packed into a magnesium container only 26½ in. diameter.

Schjeldahl verified the structural design of the bigger sphere by inflation to a tensile stress of 4000 psi for four hours. Then it was tested to destruction at 18,000 psi, proving a design safety factor of 4½.

The satellite is to be launched on a ballistic trajectory this fall with a *Thor* booster. The first orbital launching is scheduled for mid-1962, with use of a *Thor-Agena B* vehicle, down the Pacific Missile Range.

Echo II is expected to have a much longer useful life than *Echo I*, which is still in orbit. *Echo I* can be used as a communications reflector, but the quality of the reflected messages has degraded because of wrinkles in the surface.

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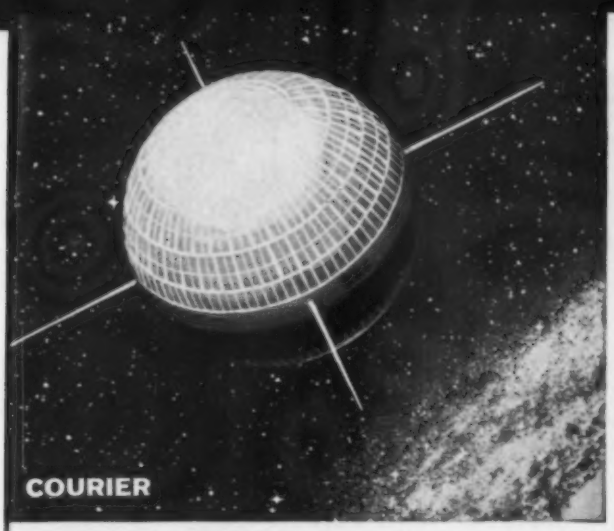

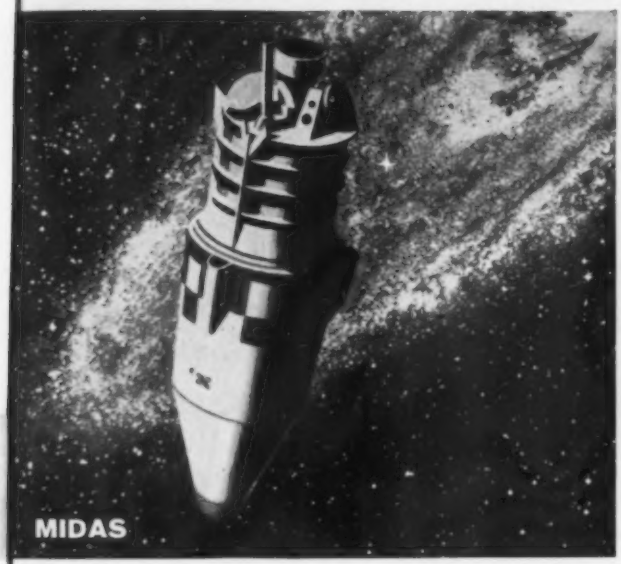

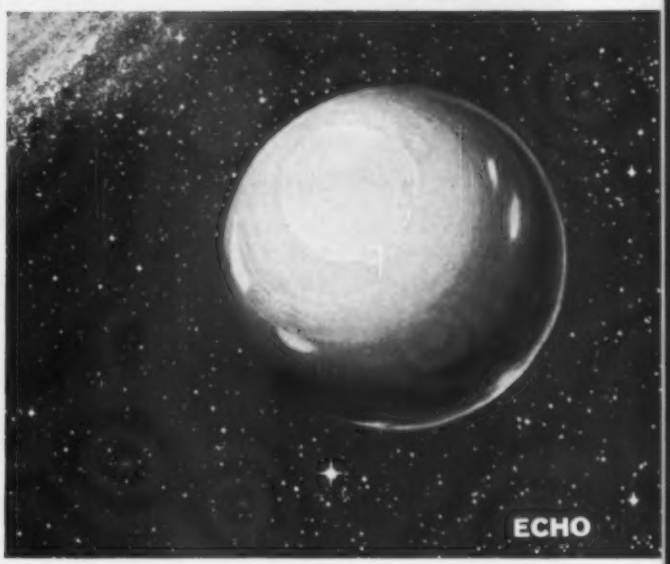

Philco Achievements in Space Technology

Philco has made many major contributions to the nation's vital space programs. COURIER, the world's first advanced communications satellite, was designed and built by Philco. Philco played a major role in the development and installation of the complex communications, command, tracking and data systems for the DISCOVERER program. Space-borne and ground communications systems for MIDAS and other satellites have been Philco designed. Philco developed and installed the tracking and receiving systems for the Air Force Passive Satellite Relay Link, which utilizes the ECHO satellite. In the field of human factors engineering, Philco has developed personnel subsystems for several major space projects. Philco also produces the world's largest 3-axis satellite tracking antennas.

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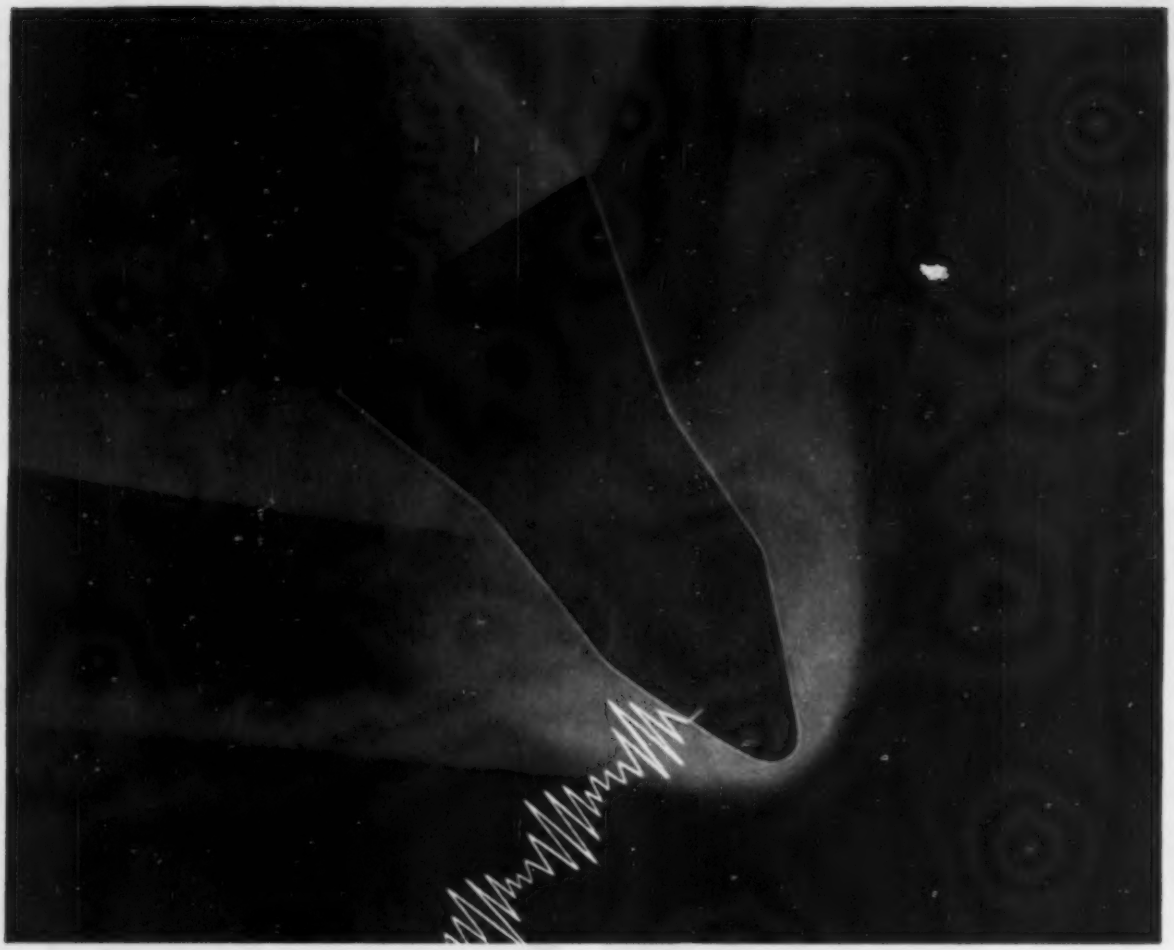

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Piercing the plasma sheath...

When ICBMs, satellites or space probes re-enter the earth's atmosphere, frictional heating is so intense that air surrounding the vehicle becomes a "plasma sheath." This acts as a barrier to conventional radio telemetry. AVCO/RAD has developed a Direct Re-entry Telemetry (DRET) system for the U. S. Air Force. The DRET system has been flown on Atlas and Titan ICBMs and has successfully transmitted signals to airborne monitoring equipment. Engineers and scientists at AVCO/RAD are also working on techniques for continuous communications with re-entering manned vehicles, as well as on other conditions in which a plasma barrier exists and where signal penetration is required.

Airborne re-entry tracking team of Avco's RAD Division monitor an Avco Mark 4 re-entry vehicle launched by Titan ICBM.

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Their job reaches into virtually every area of scientific pursuit on earth and in the sky. The objective: Greater control of man's environment under every condition, from the oceans' depths to outer space. Each member of the team contributes in his specialty to the solution of the total problem.

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Fresh evidence . . .

Soviet Manned Spacecraft Is Winged

EVIDENCE mounted this week that the manned Soviet Cosmic Ship *Vostok* was an early prototype of a winged military spacecraft.

Informed sources said new information matches earlier data and reports that the *Vostok* was a winged vehicle which used glide techniques to re-enter the atmosphere and land in a preselected field after orbiting the earth.

The new information was based in part on fairly detailed drawings appearing on recently-released Soviet postage stamps, which are usually considered by the intelligence community to be highly accurate. Up to now the Russians have not disclosed the precise configuration of *Vostok*.

The drawings depict the *Vostok* as a glider similar in concept to the Air Force *Dyna-Soar*. What appears to be the upper stage of the *Vostok* booster was depicted as having fins, as will the modified *Titan II* to be used for launching *Dyna-Soar*.

The drawings also indicate that the *Vostok* was similar to earlier spacecraft used by the Russians to launch dogs into orbit and return them to earth (M/R, April 17, p. 14).

The growing evidence that Russia is successfully launching winged spacecraft is of great concern to U.S. Air Force officials.

• **Military significance**—Such launchings have a two-fold significance:

—They mean Russia has already solved the difficult problems of maneuverable re-entry. These are the problems that the long-starved *Dyna-Soar* program is aimed at solving over the next two to five years in preparation for designing operational military spacecraft.

—They offer new evidence to support the already widely held conviction in the Air Force and many technical circles that the Soviet space program always has been aimed directly at achieving military dominance in space.

Wings or other surfaces that would provide lift are considered essential design features for military spacecraft that would operate on missions in the atmosphere as well as in space. These features are not considered essential for purely scientific spacecraft which do not have to maneuver or land at preselected points.

Military planners stress that military domination in space between the earth and the moon can only be achieved through control of the air and space near earth with military craft operating in both environments.

They contend that the development of winged military spacecraft by the Soviets would enable them to completely deny space to U.S. satellites and spacecraft and pose the threat of even denying the United States the ability to use space for R&D tests.

Moreover, military strategists contend that military spacecraft would enable Russia to pose an alternate strategic threat to currently-planned land, sea and air-based systems. This could be done with orbital or aerospace bombers.

In brief, Russia in a nuclear war would have the last button in space. ⌗

NEW SOVIET STAMPS depict (detail above and at upper left, below) a winged Vostok on top of what is apparently the upper stage of a huge Soviet booster. Other stamps show (bottom left) a winged Sputnik IV spacecraft launched May 15, 1960 and (bottom right) a winged dog-carrying Sputnik V launched Aug. 19, 1960. Czech stamp (upper right) depicts Soviet Feb. 12 Venus probe.

New Gap: U.S., USSR Astronomical Units

U.S. AND SOVIET radar-bounce-off-Venus measurements of the astronomical unit differ by 88,000 miles.

And the United States says Venus' rotation is very slow—perhaps with a period of 225 days—while Russia has calculated a period of 9 to 11 days.

Both nations performed the experiments between March and May, when the earth and Venus were passing close to one another. The closest distance—or inferior conjunction—was on April 10, when the planets were separated by 26.3 million miles. Inferior conjunction occurs every 19 months.

The U.S. experiments were conducted by Jet Propulsion Laboratory, operated by California Institute of Technology for the National Aeronautics and Space Administration. The Soviet Academy of Sciences sponsored the work reported by Academician Vladimir Kotelnikov and Prof. Isoif Shklovskiy. The location of the Soviet work was not disclosed.

JPL reported last week that its experiments with the Goldstone 85-ft. deep space antennas at Goldstone, Calif., developed a value of the astronomical unit—the average distance between the sun and the earth—of 92,956,000 statute miles, plus or minus 1000 miles. The work was done under the supervision of Walter K. Victor and Robertson Stevens.

Tass quoted the Soviet Academy as reporting May 11 that the unit figures out to 149,457,000 kilometers—which equals 92,868,000 statute miles.

JPL said it transmitted on a frequency of 2388 megacycles. Tass said only that the Soviet transmission was in the middle of the decimeter band—apparently in the neighborhood of 1000 megacycles.

JPL said the frequency of the return signal was spread from 5 to 10 cps, indicating that the rotation rate is extremely slow—perhaps as slow as once per Venusian year of 225 earth days. Victor said the final results of the spin rate calculation depend on the yet-to-be-figured orientation of the spin axis, which he said is difficult for such a slowly rotating body.

Kotelnikov and Shklovskiy said their observations indicate that some reflecting zones on the planet's surface differ by as much as 80 meters per sec. If it is assumed that the rotation axis is perpendicular to the line joining the earth and Venus, they said, the period approximates 11 days. But if the axis is inclined as predicted by the U.S. astronomer Gerard Kuiper, they commented, the period approximates 9 days.

The Tass report gave neither the frequency of the Soviet transmission nor the amount of the band widening. However, it said full results will be published later in scientific journals.

JPL began bouncing signals off Venus March 10 and continued the experiments daily through May 10. Its signals indicated Venus has a reflectivity of 12%—similar to that of the earth.

R. J. Parks, director of JPL's planetary exploration program, told M/R that success of the experiment in refining the astronomical unit was "the payoff to a multimillion-dollar calculated gamble" in connection with design of the first U.S. Venus spacecraft, *Mariner*, on which JPL began work last year.

"Our whole design was based on the assumption that we would get a better determination of the astronomical unit before the vehicle flew," Parks recalled.

Victor, co-director of the Venus radar experiment, said results would make possible:

—Acceleration of planetary exploration by at least one and a half years.

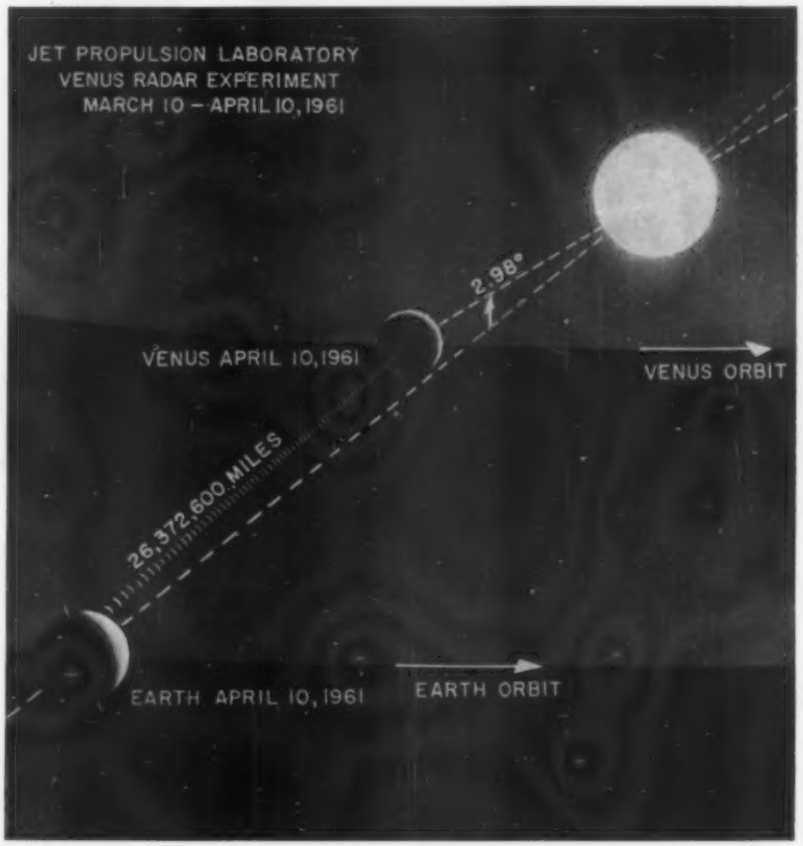
—Simplification of spacecraft design.

—Savings of millions of dollars in research and design.

—An increase in spacecraft communication range to 300 million miles (compared to about 20 million achieved with *Pioneer V*).

Without the new figure for the astronomical unit, Victor said, the first U.S. Venus probe next year would miss that planet by at least 20,000 miles, and another attempt could not be made for 19 months.

A "significant simplification" in design of planetary probes will be possible, he said, because target planets now can be located with such high accuracy that "it no longer is necessary to rely on development of a long-range terminal tracking device. Instead, the already developed midcourse guidance system can be used to guide the spacecraft." ■



JPL CHART shows how signals were bounced off Venus to measure astronomical unit.

Orbital Work Can Aid Moon Landing

RENDEZVOUS and orbital operations can help speed the U.S. manned landing on the moon, a high space agency official says.

Milton W. Rosen, deputy director of NASA launch vehicle programs, told the House Space Committee last week that orbital operations might extend the capability of *Saturn*, and might speed the achievement of a permanent or long-term manned space station in orbit.

However, Rosen said orbital operations will require extensive development to achieve operational capability. The first step in the development, he added, would be an orbital docking demonstration, in which two-payloads would be joined in orbit.

It is understood that NASA plans to launch two *Agena B* satellites for the demonstration, if funds are provided to obtain the launch vehicles in Fiscal Year 1962. Rosen said under questioning he believed $8 million should be appropriated.

One of the advantages of rendezvous and orbital operations is leapfrogging the lengthy process of "man-rating" the *Nova* launch vehicle, Rosen contended. Instead of waiting for the extensive testing required to make the *Nova* safe for manned flight, its upper stages could be launched into orbit as an unmanned carrier. Then a manned spacecraft be carried into orbit by a man-rated *Saturn C-2*.

The manned spacecraft and the upper *Nova* stages could then be locked together and launched from orbit.

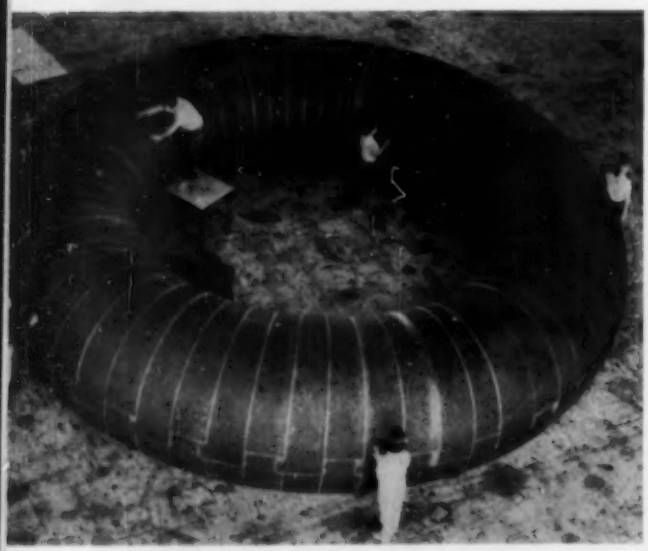
• **Other possibilities**—Another use of orbital operations might be to launch about six *Saturn C-2* vehicles to carry and transfer fuel and finally a manned spacecraft to an orbiting *Saturn* upper stage. It has been reported elsewhere that the *Saturn S-IV* stage might be considered for such an operation. It would carry sufficient propellant for braking down to a soft landing on the moon and lifting back off for return to earth.

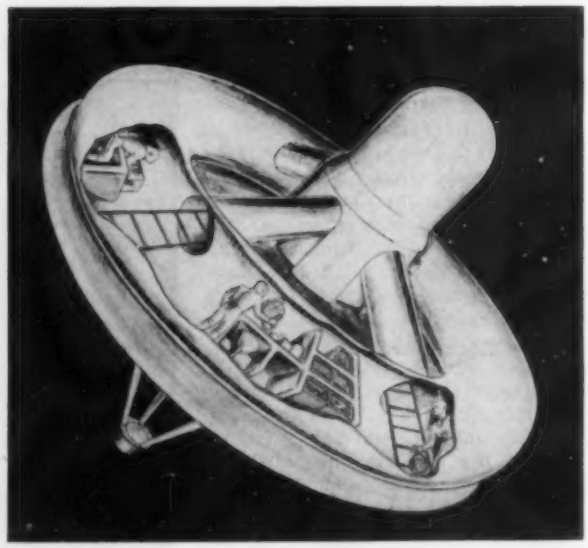
Rosen said it might be possible to land men on the moon by such a method with a smaller and less expensive launch vehicle. However, he cautioned that the operation is extremely complex and, in the end, it might not save time and have the desired reliability.

A third application of rendezvous, Rosen said, would be for rescue of the crew of a disabled *Apollo* spacecraft in orbit. If the *Apollo* should prove incapable of making a safe descent, a rescue vehicle could rendezvous, attach a powered capsule, transfer the crew and return safely to earth.

The same technique could be used for periodic rotation of the crew of a permanent space station.

Harold Brown, director of defense research and engineering, said the Defense Department is also interested in rendezvous techniques. He said there are military requirements for inspecting possible hostile satellites. ⁂





Goodyear Proposes Expandable Structures as Space Stations

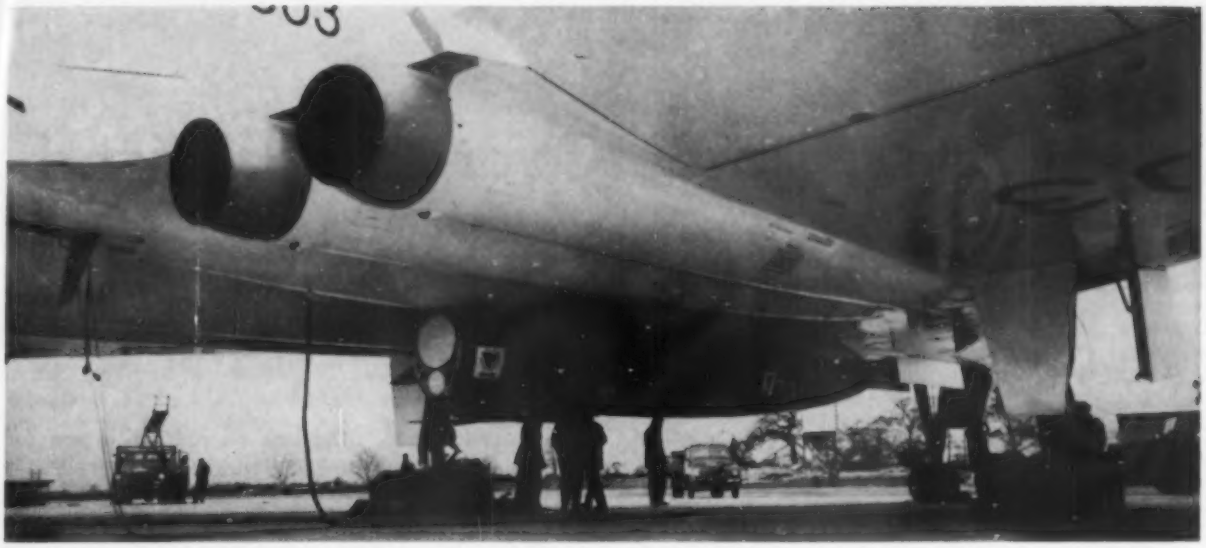
EXPANDABLE structures—folded within a rocket nose cap like the Echo balloon satellites—are being proposed for use as orbiting space stations.

In a presentation before the House Space Committee last week, Goodyear Aircraft Corp. said it would be possible to produce almost any size or shape for the space station by patterning or weaving the fabric structure in the desired final configuration. Inflation in orbit is accomplished with a suitable gas.

The major advantage of the expandable structure is that it can be assembled and inspected at the factory. Then it is deflated and packaged into a canister for handling and packing within the booster payload.

Goodyear said shapes such as spheres, ellipsoids, paraboloids, cylinders and other bodies of revolution can be fabricated in single-wall structures by proper design of the pattern. In addition, Goodyear says, it has developed a method of fabricating double-wall structures by weaving the two wall fabrics simultaneously with interconnecting filaments.

The ability to fold an entire space station into the dimensions of a relatively small nose cone would make it possible to place an entire manned space station and re-entry vehicle in orbit.



OPERATIONAL-SIZE BLUE STEEL shown slung under Vulcan will have nuclear warhead.

Blue Steel Put Into Full Production

Avro's system is Europe's only inertial missile in mass production; weapon is 'core' of U.K. defense pending skybolt

by Bernard Poirier

BRITAIN'S air-launched *Blue Steel* strategic missile has been put into full production by A. V. Roe & Co. Ltd., in an effort to outfit all serviceable Vulcan bombers as they become available.

At the same time, the evaluation program for the key weapon is being pressed at Australia's Woomera range.

Significant breakthroughs by A. V. Roe and its subcontractors during the past year have given *Blue Steel's* makers the only inertial missile production line in Europe. They have also provided the West with its only present weapon with strategic peripheral (stand-off) capability from aircraft.

Blue Steel's principal advantage, according to an Avro spokesman, is its programed ability to feint and maneuver evasively during flight to an assigned target area.

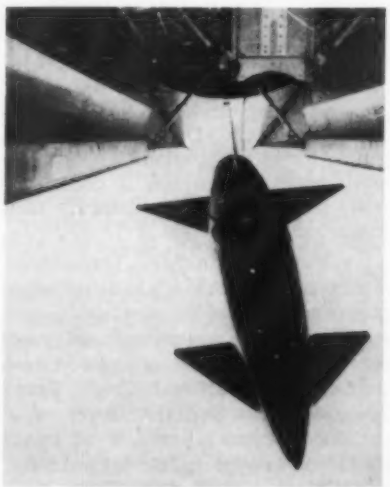
Two subcontractors have made important contributions to the Avro effort:

• **Elliott Brothers** (London) perfected the purely inertial navigation system which instantaneously adopts position fix at launch and commands servo reactions from parametrically acceptable pick-offs while in programed flight.

• **Bristol Siddeley Engines** designed and developed a new Stentor liquid rocket motor with longer burning time and reliable performance to satisfy requirements for evasion-under-power.

Since the Stentor was adopted, unofficial reports have placed *Blue Steel's* range at 500 miles. The British will station Vulcans armed with the missiles at widely scattered bases, ready for deployment in any direction.

British military conviction that *Blue Steel* could meet its objectives has solidified Avros' position, which earlier was subjected to considerable political fluctuation. For a time, the missile's future was balanced against America's Douglas *Skybolt*.



TWO-FIFTHS-SIZE test model of the Blue Steel is hoisted aboard bomber.

But *Skybolt* suffered cutbacks in the U.S. defense budget (M/R, May 8, p. 8), and when its slippage became a certainty British Minister for Defence Harold Watkinson ordered a large number of *Blue Steels* into production.

"It is a weapon for the present," Watkinson said, "and for the next few years until *Skybolt* enters service."

Top British officials, while expressing regret that the *Skybolt* system had been slowed up, asserted that the nuclear *Blue Steel* has "a very powerful punch indeed."

• **Britain's defense core**—The *Blue Steel* system outgrew its early testing facilities at Aberporth, Wales, and elaborate and farflung installations had to be built for it at Woomera.

A. V. Roe acquired buildings and facilities at Edinburgh Field, near Adelaide, about 250 miles south of the range itself. Telemetering stations were established several hundred miles apart along the flight area.

The system proved that it could arrive at a target well beyond known antiaircraft missile range, recover from each programed evasive tactic and follow its assigned course. Thus, dispersed, mobile and very difficult to defend against, *Blue Steel* is considered "the core of Britain's aerial defense." ⌗

NTC committee reports . . .

Telemetry Can Be Over-Standardized

Majority of panel of industry experts says standards—while badly needed—must be flexible; Rechtin named telemetry man of year

CHICAGO—Industry experts are warning that premature and rigid standards can throttle the progress of telemetering.

Several members of a workshop panel on telemetry standards at the National Telemetering Conference voiced their concern over this problem. These panelists and members of the NTC Standards Activation Committee—who have been studying the problem for some time—agreed that standards have not kept pace with the industry. They are badly needed, but they must be flexible and loose enough so as to aid rather than impede progress.

The Standards Committee apparently was not unanimous in this view, however. A minority held that standards should be more rigid and even, perhaps, become military specifications.

In pointing out the changing nature of telemetry, one expert said that its role had grown from a service function—gathering failure data from R&D missiles—to being the primary element in a space probe. Because the problems are very different, systems must be different.

Space systems will have to be able to handle increasing amounts of data over ever-increasing distances. As a consequence, one panelist predicted, the performance of the telemetering link must be increased several orders of magnitude over the next 4 to 5 years.

• **Rechtin honored**—Social highlight of the NTC was the annual award banquet. Dr. Eberhardt Rechtin, chief of the Telecommunications Division of JPL, was named as the telemetry man of the year. Rechtin has been responsible for much of JPL's space communications and tracking efforts. Banquet speaker was Dr. Charles S. Draper, inertial guidance pioneer, of MIT.

Luncheon speakers were William J. Coughlin, editor of MISSILES AND ROCKETS and Dr. David S. Potter, research director of GM Defense Systems Division. This year's chairman of the NTC was Robert G. Brown, director of AC Spark Plug's Advanced Development Department.

Workshop sessions highlighted the technical program. The status of telemetering in Europe was discussed by a panel of eight delegates brought here for the occasion by the Air Force. Greece, Belgium, Denmark, the Netherlands, Britain, Germany, Italy, and France were represented in the group.

One panel of educational experts discussed the need for training engineers and technicians in using telemetry as a tool in measurement decisions, and how this need can be met.

Another unique feature of the NTC was a technical session and exhibit tour held for some 600 Chicago high school science students. This reportedly was the first time such students had been allowed to participate in a professional scientific conference.

Although interest is still high in digital telemetering systems, it was evident at the conference that the original enthusiasm for PCM may be cooling off somewhat. According to some spokesmen, the industry is suffering from "hyperdigitosis"—the conviction that all problems can be solved by a liberal application of digital techniques.

Older techniques are being dusted off and improved upon and unique approaches being devised to handle specific problems. PCM, although certainly getting the most attention in both technical papers and exhibits, is not necessarily the darling of the industry that it has been previously.

• **Paper highlights**—Transducer manufacturers should immediately begin programs to supply adequate digital transducers for measurement of pressure, motion, temperature and acceleration, said Fred S. Howell, Zeigler Corp. His paper described the results of a detailed analysis of the use of transducers in ballistic missile telemetering. Classifying measurements into four groups, Howell indicated how each could best be handled.

The data transmission system for the gamma ray astronomy satellite was described by two NASA scientists, Olin B. King and Frank Emens. Pointing out the complexity of the experiment and the high initial bandwidths involved, the authors showed how optimum design allowed an overall power consumption level of less than 1.5 watts.

In another paper, King described the unique SS-FM telemetering system developed to solve the problem of vibration measurements in the *Saturn* program. The high data bandwidth capability of the system is of special interest to the industry.

Requirements for the instrumentation of *Dyna-Soar* were outlined by W. M. Moore and W. D. Mace of NASA. Their paper included the types of measurements that would be required in the vehicle and a description of the airborne systems which might be developed to meet these requirements.

Max A. Lowy, Gulton Industries, delivered a paper on an approach to self adaptive telemetry systems. He described a possible system which would transmit only data of primary interest with optimum utilization of data bandwidth.

The problems of synchronization in PCM systems were outlined in a paper by Merwin W. Williard of Dynatronics, Inc. He presented a method of word and frame synchronization detection which would allow rapid sync acquisition and still maintain synchronization with reliability in the presence of high noise levels.

One technical session was devoted to the use of telemetry in underwater measurements and another to bio-medical telemetering.

Conventioneering engineers could get their money's worth in Chicago this week. Globe Com V ran concurrently with NTC and communication experts shared their time between the two conferences. Thursday and Friday, Electronic Industries Association took over the stage with its annual convention. ⌗

Attention Ike . . .

GOP Fails to Get More Polaris Subs

HOUSE Republicans this last week sought belatedly to amend the GOP record on the *Polaris* submarine program.

The House Republican Policy Committee sought to add six more *Polaris* submarines to the $12.3 billion defense procurement authorization bill as it came up for action on the House floor.

The House passed the bill including $393 million for bombers added by the House Armed Services Committee on top of the request submitted by President Kennedy. The House rejected the GOP *Polaris* amendment 105 to 58.

The GOP amendment added an ironic footnote to history. The Eisenhower Administration consistently cut back Navy requests for *Polaris* submarines. However, the Kennedy Administration has accelerated the *Polaris* sub construction program and added 10 more to the final Eisenhower budget proposals.

Rep. Charles S. Gubser (R-Calif.) originally attempted to add six more *Polaris* subs on top of the Kennedy requests when the Armed Services Committee was voting on the bill. The price-tag on the proposal was $697 million.

Gubser argued that the extra authorization should be included in order to insure the continuity of the *Polaris* submarine construction program. He noted that so far the Kennedy Administration has not committed itself to build more than 29. The Navy wants a fleet of 45.

The House Republican Policy Committee later agreed to support Gubser in trying to add the amendment again on the House floor.

• **Too "unrealistic"**—Chairman Carl Vinson (D-Ga.) of the Armed Services Committee told the House six more subs were "unrealistic" because they could not be built for several years even if the money were authorized. He said Congress should not try to decide unnecessarily now what would be needed in the future.

The authorization bill itself cleared the House with little change from Kennedy's requests other than the addition for bombers. The Senate already has passed a similar bill except for the addition of $468 million for bombers. The bill now must go to a conference committee for adjustment of differences.

The additions for bombers resulted from doubts raised by members of both the Senate and House Armed Services Committees as to the wisdom of ending production of all manned bombers in the United States.

The production cut-off originally was proposed in the final Eisenhower budget. Kennedy went along with it.

However, congressmen contended that shutting down bomber production would be premature. They said that the incoming missile systems still were not reliable enough. And they said more bombers will be needed to make the *Skybolt* air-launched ballistic missile worthwhile.

Behind the congressional arguments also was concern caused by the Administration cut-back in the B-70 R&D program.

Except for the B-70, the United States does not have a new manned strategic bomber under development. A number of Air Force officials have repeatedly pointed out the need for new manned bombers to combat mobile missile systems and to provide a nuclear second strike hunter-killer force.

As for reliance on the big missiles, Air Force Secretary Zuckert bluntly told the Senate Armed Services Committee:

"I think that it is very important that the people of this country do not get the feeling that we have a real missile capability or that we are going to have it for the next couple or three or four years. In the first place there are not a lot of them today. There are very few operational, and there will be few operational in my opinion for some time to come." ⌗

Highest Priority Urged for the Rover Nuclear Rocket

THE PROJECT *Rover* nuclear rocket program is being recommended for a DX priority, the nation's highest.

In a staff report submitted by Chairman Overton Brooks (D-La.), the House Space Committee calls for selection of engine and vehicle contractors by the National Aeronautics and Space Administration "at the earliest practicable date."

The committee also urges:

—Providing the joint NASA-Atomic Energy Commission Space Nuclear Propulsion Office "with sufficient authority effectively to direct the progress" of *Rover*.

—Using the talents of the AEC's Los Alamos Scientific Laboratory in research on advanced reactors as much as possible, leaving the engineering work to industrial contractors.

—Restudy of the funding level for Nevada facilities with the objective of providing adequate support and test facilities when needed.

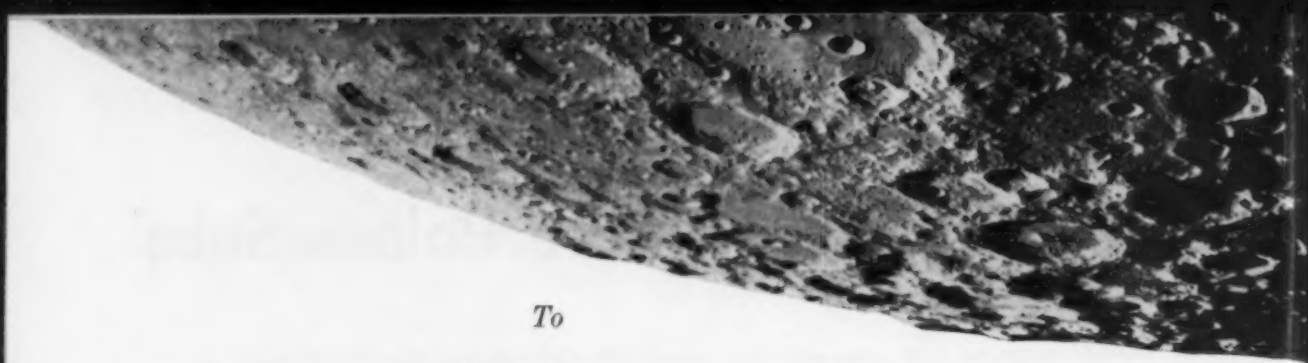
The committee cited administrative delays in *Rover* last fall in support of its call for giving more authority to the SNPO, headed by Harold B. Finger.

Results of the *Kiwi-A3* test firings were so good last fall that SNPO decided to cancel a proposed NASA *Nerva* flight engine design study contract and proceed immediately to the selection of an engine contractor. The aim was to speed the program by several months.

By the end of November, the technical statement of work was completed. However, the requests for proposals were not sent to the engine contractors until February. The committee said details bearing on method of selection, procurement principles, method of financing and the roles to be played by various field elements of AEC and NASA caused disagreements that resulted in a delay of more than two months.

"Delays of this nature raise questions as to whether the SNPO functions at a sufficiently high management level that decision bearing upon matters requiring the cooperative effort of AEC and NASA can be made in an orderly manner," the committee commented.

The committee reported it is encouraged by the decision of NASA to begin a development program for the *Nerva* engine. But it added, "The committee is not reassured about the program for development of a suitable vehicle. Industry witnesses have stated that solution of the inevitable interface problems between engine and vehicle requires that both development programs proceed in parallel." ⌗



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systems

reliability

CALTECH'S JPL RANGER, to carry research instrument packages to the moon, will rely upon precision design, construction, testing and performance of Motorola electronic equipment. Comprehensive measurements of operational and navigational data aboard will be assembled for transmission by its Flight Data Encoder. An all solid state Transponder generates the telemetry carrier, receives ground commands, and translates carrier frequencies for two-way Doppler velocity measurements. ☆ In laboratories and at launch site, Payload Test Sets will check out the spacecraft RF communications system. At NASA's transmitter and receiver sites, Calibration Beacons will check command transmitter performance and radiate precise signals to test telemetry receivers. ☆ Motorola's participation in Ranger lunar probes demonstrates its space communications capabilities for frontier programs.

Military Electronics Division **MOTOROLA**

Qualified technical personnel are invited to apply

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Technical Countdown

ASTRONAUTICS

Re-entry Corridors Vary Considerably

A lift/drag ratio of 2—as in a *Dyna-Soar* glider—would enable the pilot of a returning spacecraft to vary his landing point up to 9000 miles longitudinally and about 2500 miles laterally—so that the returning vehicle might land anywhere in the continental United States. NASA says that with an L/D ratio of 0.4 to 0.7—as indicated for the *Apollo*—control will be limited to about 1000 miles longitudinally and a few hundred miles laterally.

ADVANCED MATERIALS

BeO Coating Breakthrough Announced

Numec has deposited a coating of non-porous beryllia on small particles of uranium dioxide in layers up to 100 microns on 100-micron-diameter particles. The BeO coatings have a potential in nuclear rockets because their thermal conductivity is higher than that of most oxide coatings.

Solid-Fuel Mixer Developed

A vertical mixer with interchangeable mixer bowls, which cut mixing time by quicker loading and unloading operations, has been developed by J. H. Day Co. Three vertical agitators overlap and intermesh to increase efficiency some 30 to 80%, Day reports.

Saturn Bulkheads Explosively Formed

Explosive forming of 70-in. hemispherical *Saturn* bulkheads is under way at Ryan Aeronautical Co. A 13-ton concrete and epoxy die has been fabricated to form the one-piece aluminum components.

Hi-Temp Plastic Breakthrough Soon

A breakthrough in high-temperature plastics to permit use of an all-plastic thrust chamber in liquid-propellant rocket motors will be announced shortly. Experimental plastic chambers have been successfully test-fired at medium chamber pressures. To eliminate ablation technique which alters the cross-sectional area of throat, one solution is a plastic which conducts surface heat through conductive filaments imbedded in the material. The plastic chamber is expected to be used first in low-pressure systems for vector control and positioning of space vehicles.

Largest Aluminum Casting Reported

One of the largest aluminum alloy hydrodynamic structures ever cast is reported by U.J.B. Foundary and Pattern Co., Long Beach, Calif. The modified conical structure, 5½ ft. high, 4 ft. in diameter at the base and 2 ft. at the top, had a maximum wall thickness of 0.375 in. Integral stiffeners and bosses required sections ranging in thickness from ¼ to 4 in.

New Type Air Bearing Tested

Boeing engineers have developed a new and simpler arrangement for using air as a bearing surface, bypassing some of the method's previous disadvantages. Using step-bearings supported by air from a single hole rather than from multiple tiny orifices, the new device is reportedly cheaper and more rugged. Test units have been run at speeds up to 100,000 rpm in temperatures from −330 to +600°F.

ELECTRONICS

IR Advances Needed

The Air Force is looking for a way to boost capability and accuracy of infrared-based tracking and reconnaissance devices. Latest move is award of an R&D contract to Electro-Optical Systems for thin-metal-film, bolometer-type IR detectors. The main objective is a state-of-the-art advance from single-detection elements to multi-element, probably mosaic-type, arrays.

PILAC Clocks Nuclear Events

Los Alamos Scientific Laboratory has successfully clocked nuclear events occurring in a nanosecond through use of a device called PILAC—Pulsed Ion Linear Accelerator. The system incorporates a compression magnet and converts a steady, or d-c, current of high-energy ions into a train of intense, equally spaced bursts, each only a fraction of a nanosecond long.

Minuteman Circuits to Production

First production run for high-reliability circuit assemblies for *Minuteman* electronic systems is scheduled to start soon under a contract just awarded to Melpar, Inc. by Autonetics. Melpar will produce the electronic building blocks for guidance, control and checkout systems. Components to be used were developed in a unique two-year program for upgrading reliability of semiconductors; the effort is expected to yield components 100 times more reliable than those available a short time ago.

Perpetual Fuel Cell Next?

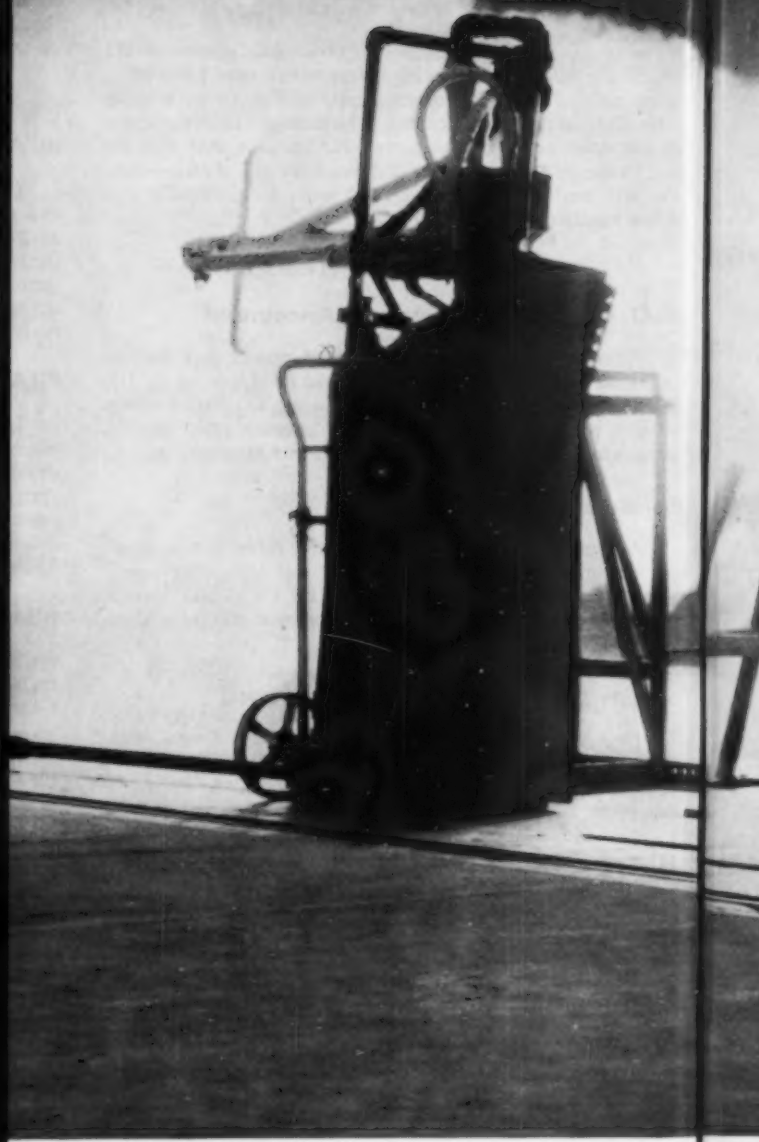
An experimental regenerative fuel cell which can be designed to deliver thousands of kilowatts and operate indefinitely is under development at Hoffman Electronics. A working model of the sodium amalgam-chlorine primary fuel cell, not much larger than a man's wrist watch, produces 1 watt of power, compared with ⅔ watt from a flashlight cell. It also can use bromine to generate electricity by chemical reaction, according to Hoffman.

PROPULSION

Toxic Leakage Detector Revealed

An electrochemical instrument that will detect air mixtures of highly toxic UDMH (unsymmetrical dimethyl hydrazine) has been developed. Capable of measuring UDMH to 1 part in 4 million, it far exceeds human capability of detecting to about 8 parts in 1 million—a level above human tolerance. Called Olfactron, its developer, American Systems, Inc., says device also can be used to detect leakage of hydrazine, nitrogen tetroxide, and other toxic propellants. Instrument reportedly will be used at *Titan II* bases.

SPACE . . . IMAGINATION . . . ENERGY



HERE'S HOW WE MEASURE MISSILE MUSCLE

This is one of the test-bays at the Hercules-owned-and-operated plant at Bacchus, Utah. Here the third-stage engine for the Minuteman rocket was developed and is manufactured for the Air Force. The advanced second-stage Polaris engine, developed for the Navy at Allegany Ballistics Laboratory, is also being manufactured here. Hercules' Bacchus plant is a fully integrated facility for research, development, and production line manufacture of high-specific-impulse solid-fueled rocket engines.

As each new design-idea is proved out in roaring flame, a net of cunningly placed transducers take the engine's pulse, its temperatures, check its pressures, stresses and thrusts. This welter of information is fed, at 20,000 bits

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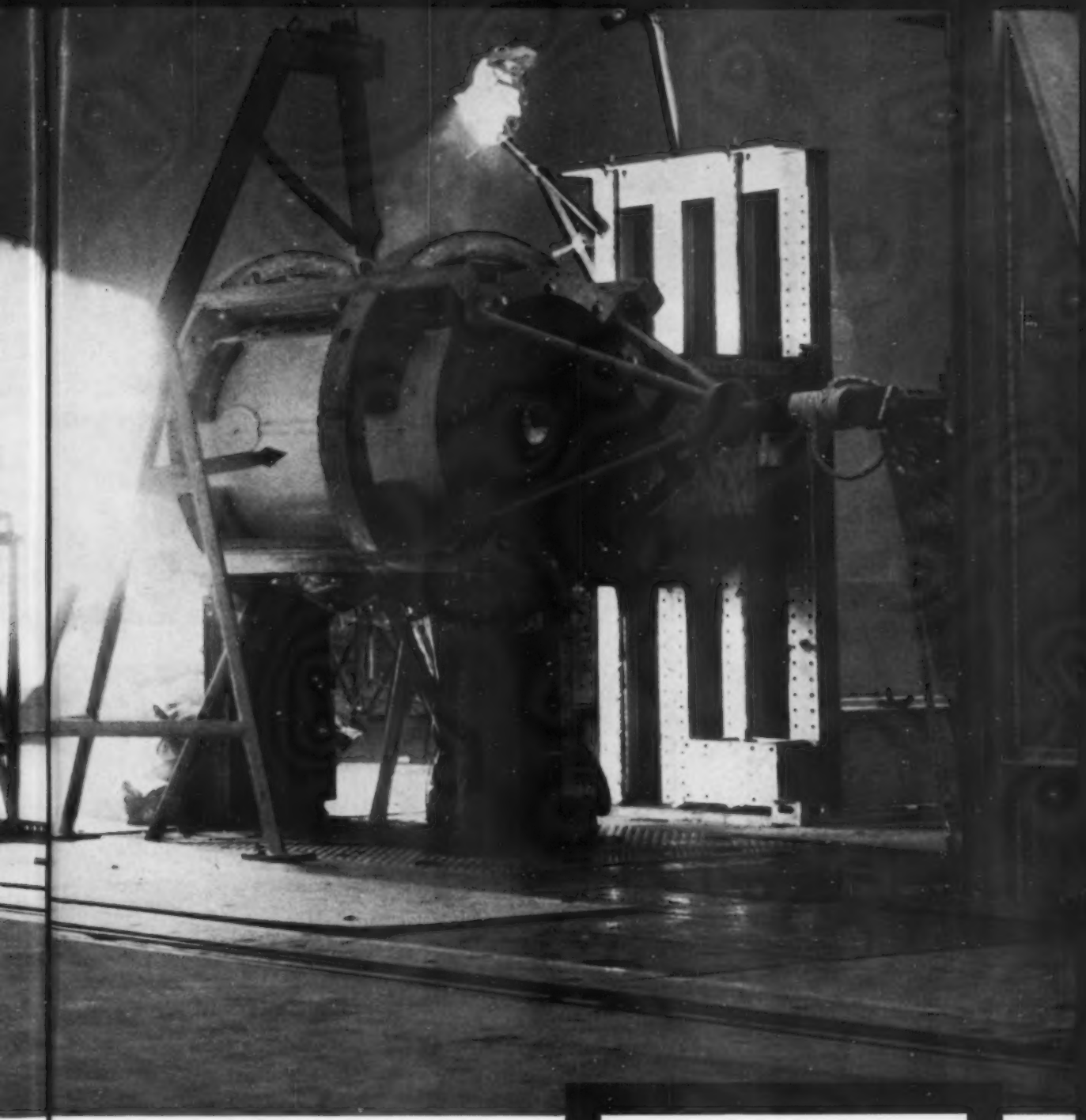

per second over 240 separate input channels, to a central data acquisition room where it is permanently recorded on synchronized magnetic tapes. Meanwhile, as many as twelve high-speed cameras exposing up to 3,000 frames a second on a quarter-mile of film, keep a visual record of everything that happens with thousandths-of-a-second accuracy.

Thus, each test of component, propulsion unit, experimental design or completed engine yields a maximum amount of information ready for computer analysis and integration to advance both design criteria and manufacturing methodology. This is just another example of Hercules imagination in propulsion engineering.

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DYNA-SOAR

APOLLO CONCEPT

AEROSPACE PLANE CONCEPT

by James Baar

MAN IN SPACE

The Nation Needs to be Told Why It Should Invest Men and Vast Wealth in Reaching To the Moon and Beyond—The Best Case May be Made on A Stark Basis of Survival

THE BASIC space question before President Kennedy and the nation is why the United States should send men into space and to the moon.

Many officials, scientists and industrialists feel that U.S. space programs will continue to flounder until that question is convincingly answered and the answer transformed into national policy and goals.

Essentially, there are three main reasons why the United States might want to send men into space and to the moon:

The first is for science—and the possible resulting commercial and human gain.

The second is for Cold War prestige.

The third is for military security.

All are interrelated. All are questioned by one expert or another and one group or another. But only the third—military security—carries with it a mandate of absolute necessity if it is valid.

The yardstick by which each reason must be measured is the cost, in money, in time and in talent.

Estimates of the cost of placing men on the moon and bringing them back to earth have varied from $10 billion to $40 billion spread over the next six to eight years.

These figures are being argued over interminably. There are many variables, psychological biases, and complete unknowns. Personal ambitions and reputations are cranked into all calculations. Probably the only consensus that might be safely arrived at is that a space program aimed at putting men on the moon would be a very hungry consumer of tax dollars. Moreover, there would be a vast consumption of scientific and engineering talent and other resources. In brief, the total cost will be very high.

Rubbery as this yardstick might be, each of the main reasons for putting men into space must be measured by it. Nor is it impossible to do so.

• **Scientific**—Begin with science. There is much about the universe that scientists wish to learn in space. Space exploration already has extended the boundaries of human knowledge. And to take only one example, astronomers have contended that observations made from satellite-borne telescopes will give astronomy its greatest advance in hundreds of years.

As for applied science, communication and weather satellites are expected to prove to be multibillion-dollar boons to mankind. A satellite laboratory is expected to aid medical research.

However, these and other possible but still unknown gains can be achieved without man leaving the earth. From a scientific and applied scientific point of view, sending men into space is of questionable value.

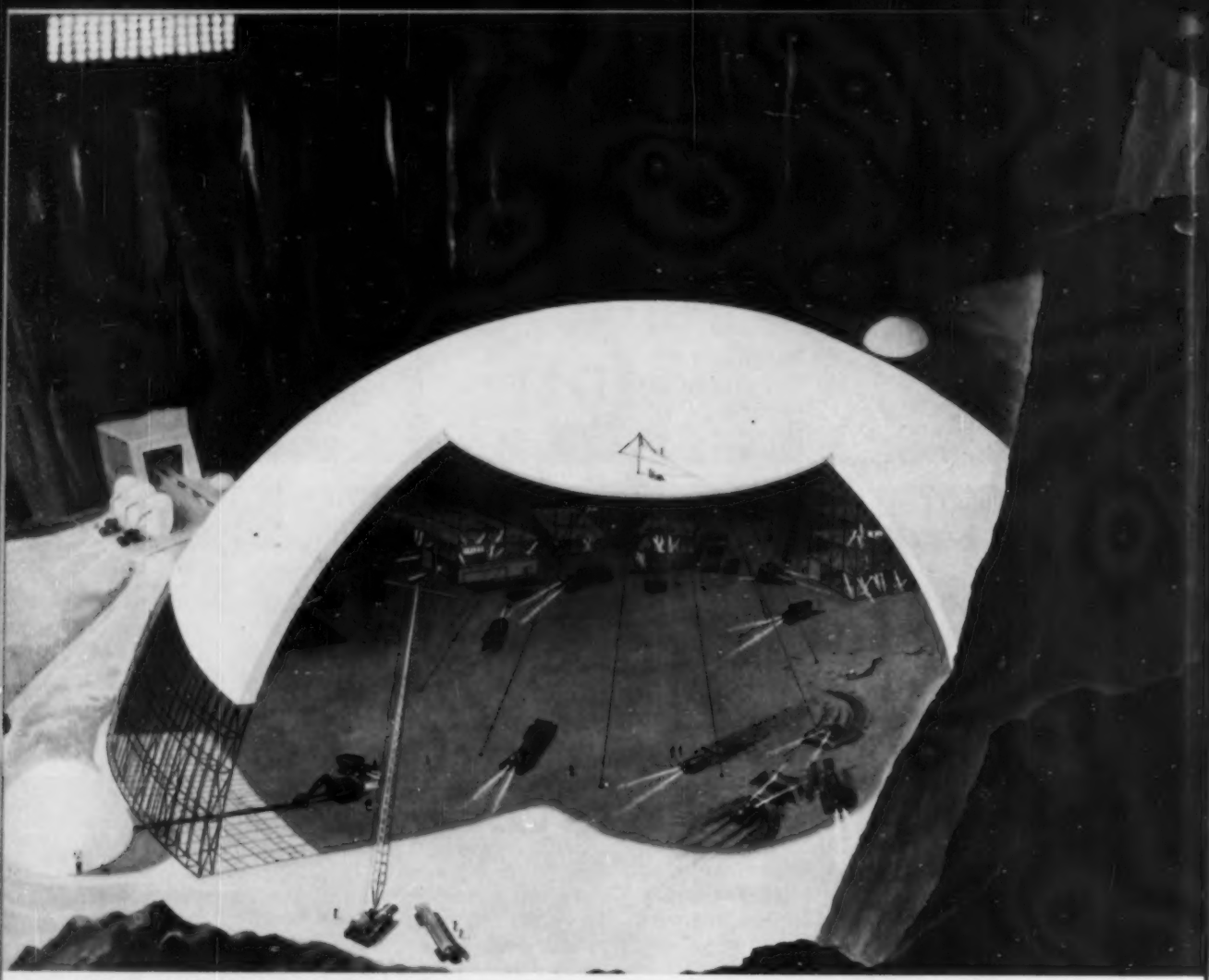
• **Wherewithal?**—Also, it is extremely questionable politically whether any great enthusiasm can be engendered in the heart of the American taxpayer for spending billions of dollars in crash programs for the advancement of science—pure or applied.

Certainly, it has been most difficult to rally much support to spend billions of federal dollars in crash programs to build public schools, cure heart disease and cancer, or conduct basic research in hundreds of scientific fields.

Therefore, taken by itself, the value of "peaceful uses of space" as a means of obtaining large-scale fiscal support for putting men into space appears extremely small.

• **Image-making**—But "peaceful uses of space" must be taken into consideration with the second possible reason for a manned space program—prestige.

Since Oct. 4, 1957, Russia has used its space activities to harvest tremendous jackpots of propaganda. Before 1957, Russia was thought throughout much of the



LUNAR BASE CONCEPT developed by GE is predicated on theory that there is water under moon's crust. Artist's drawing shows nuclear power unit (left rear) which would be used to extract hydrogen and oxygen for life support and engine fuel.

world to be backward technologically and scientifically. *Sputnik I,* in the words of Madison Avenue, reversed this image.

The new image has been enlarged over the last four years, as Russia moved from space triumph to space triumph. America's continually lagging space efforts have done little more than corroborate the message beamed to the world by Moscow commissars in gray flannel suits. And U.S. prestige was further undermined by repeated denials from American officials that the United States was not in a space race while the United States continued to trot slowly.

However, it is not necessarily correct to deduce that the obvious course for the United States is to send men into space to counter Russian propaganda gains.

On the basis of prestige alone, the United States could buy far more lasting prestige by harnessing the H-bomb for commercial use; helping abolish famine by developing vast new sources of food in the sea; or eliminating disease. These also are the kinds of pay-envelope programs about which voters are traditionally more interested in hearing.

• **The big threat**—This leaves the third possible reason for a man in space program—military security.

From the night that news spread that *Sputnik I* had been launched many U.S. military men and space experts have looked upon the Russian space program as a one-track military effort directed at domination of space.

Over the last four years the Soviets have not disproved these prophets. Major step by major step, the Soviet space program has marched toward developing the capability of placing large military spacecraft in orbit and establishing military bases on the moon. Scientific gains that did not contribute to this program have been purely secondary.

As one top astronautics expert recently put it dryly:

"In spite of all official Soviet bows to science, and no doubt much genuine devotion on the part of individuals in the Soviet space effort, I would say that their effort is lead by strategists, not by scientists."

The direction of Soviet space efforts has by now become so obvious that official U.S. government apologists have been able to make claims that the United States is ahead of Russia in scientific exploration of space. As Russia has built bigger and bigger boosters and orbited manned spacecraft leading to military weapon systems, the United States has spent the bulk of its relatively small space budget on beating Russia in the collection of certain types of scientific data.

The result has been intermittent periods of public alarm usually quieted by soothing official statements from the White House and NASA.

Many top officials, including former President Eisenhower, have scoffed at the notion that there could be any military significance in the moon or the

Soviet space program. However, some of these scoffers have become quieter in the face of the Soviet Venus shot and the orbiting of Soviet Cosmonaut Gagarin. At the same time, many congressmen have made increasingly worried noises in public.

Unquestionably, the political climate for a greatly expanded U.S. space program has improved. But the goad clearly appears to be fears of Soviet military intentions in space—not Soviet scientific or propaganda gains.

So far, the White House has not indicated its appreciation of this. President Kennedy is still talking about prestige and scientific gain and then questioning whether "$20 billion or $40 billion" is too high a price to pay.

At the same time, all indications have pointed toward greatly increased money requests for NASA and far smaller ones for military programs.

• **Strictly R&D**—At present, there are only three man-in-space programs in being in the United States worthy of the name: NASA's *Mercury*, the AF-NASA *X-15* and the Air Force's *Dyna-Soar*. Everything else in this area is in the study stage or in somebody's head.

Here is the total funding for the three programs through FY '62: *Mercury*—$362 million; *X-15*—about $160 million; *Dyna-Soar*—$200 million.

All three are R&D programs. The *X-15* and *Dyna-Soar* are aimed at the development of military spacecraft capable of maneuverable re-entry and controlled landing. *Mercury* has the more limited goal of testing a man's reactions to orbital flight.

Beyond these programs, the Air Force has a wide range of studies such as *ASP*, an aero-space plane capable of internal rocket power fueled by the atmosphere; *Slomar*, aimed at developing manned and unmanned space logistics craft; *MTSS*, a military space station; and *Smart*, space maintenance and repair techniques. NASA has *Apollo*, a manned spacecraft designed to orbit the earth and later land on the moon.

Funding for such studies as these is usually under, rather than over, a million dollars each. For example, *GSS* (Global Surveillance System) studies is funded by the Air Force for a total of about $1 million, *ASP* about $2 million. *Apollo* is funded by NASA for some $750,000.

• **Booster doldrums** — Except for *ASP*, all of these studies are dependent on the development of large boosters—as *Mercury* has been dependent on *Redstone* and *Atlas*. However, to date only the 1.5-million-lb.-thrust *Saturn* is being pushed with urgency. All other big booster programs projects in the National Booster Program run by NASA are moving relatively slowly.

Meantime, Russia is already believed to have developed a booster in the *Saturn* class. One technically informed source has estimated that the booster used to orbit Gagarin and the *Vostok* spacecraft developed as much as 2 million pounds of thrust.

Also, some informed sources contend—and recent evidence clearly indicates—that the *Vostok* was winged like *Dyna-Soar*.

In any race for military domination in space the Russians are clearly well ahead even if some of the lowest estimates of Soviet capabilities are used. Using the higher estimates makes the prospects of overtaking the Russians discouragingly dark.

• **Fear and precedent**—Some military men fear that the first consequence of the Soviet military space lead will be the early destruction of U. S. reconnaissance and communication satellites. The next could well be the launching of Soviet orbital bombers.

To combat this threat, Air Force leaders have called for the development of manned offensive and defensive spacecraft. They stress the need for manning such craft in order to have the decision-making powers of a pilot rather than having to rely on machines.

This is the type of military challenge that Air Force Secretary Eugene Zuckert obviously had in mind last month when he told the Senate:

"The United States and the Free World must insure that the means of earth domination inherent in space mastery be not pre-empted by the enemies of freedom . . . The lesson is that through and from space, earth can be dominated."

There is much political precedent to show that the American public would support a vastly expensive man-in-space program to meet this kind of threat. There is little precedent that they would support it for any other reason.

However, it might be possible for Kennedy to use the fear created by this kind of threat to win support even for costly scientific man-in-space programs that would feed into more modestly-funded military programs.

The question then would be two-fold:

• How long would the American people support projects aimed at disguised goals?

• Could such projects, partly crippled by having confused goals, enable the United States to head off a Soviet military challenge in space? ⌗

'Best Answers' on Space Plans Are General

U.S. space programs have consistently suffered because of a lack of clearly defined goals.

In an attempt to pin down precisely where NASA hopes to go with its man-in-space program, M/R submitted the following questions to the agency and received the subsequent replies.

At no point can it be interpreted as offering much illumination either on the hard goals of current or future programs. Instead, the "best answers" as to NASA's program goals continue to be given in generalities. Meantime, Russia is driving to put a man on the moon by 1967.

The four questions:

Q: How many manned capsules do you plan to orbit under the present Mercury program?

A: NASA hopes to launch the first manned orbital flight before the end of 1961. The number and nature of subsequent manned orbital flights will depend on the results of the first manned orbital flight.

Q: On a shot-by-shot basis, what specific scientific experiments are being planned for each capsule? Please identify each shot by its approximate launch date.

A: The goals running through the manned flight program are (1) determination of man's stability to function during periods of weightlessness (2) to determine the psychological and physiological effects of space flight on man and (3) to advance space flight technology.

Q: What are the steps in-between the initial 3-orbit Mercury flight and the two-week Apollo trip? In particular, please detail how each intermediate experiment will build on your knowledge of how to support a man in space for long durations.

A: The steps between the three-orbit Mercury flight and the two-week Apollo flight are now under study. While a detailed answer to this question is not now available, NASA has said that it plans a multi-man earth-orbiting space laboratory between Mercury and the manned lunar missions.

Q: How much funding would NASA need to proceed with an R&D hardware contract for Apollo in FY '62?

A: The answer to this question . . . also is under review.

Hazards cited . . .

Science Takes Dim View of Man In Space

Bulk of scientists say the risks and costs are too high and knowledge to be gained is limited in value—but M-I-S is not without proponents

IF U.S. military posture and prestige were not involved, there probably would be no man-in-space project.

Indeed, the great weight of scientific opinion that has influenced government decisions on space spending has for years favored instruments over man. Even here, this country has lagged.

The U.S.'s late start in astronautics can be traced no further back than to 1956 when, apparently, a formal program of military satellite development began in the Air Force. Germany had started its astronautics program during World War II, and the Soviet Union in 1949.

The U.S. reluctance to send men into space was vocalized last year by former President Eisenhower, who—undoubtedly on the advice of his scientific consultant, Dr. George B. Kistiakowsky—severely questioned a follow-on to *Mercury* and gave only minimal funds to *Apollo*.

The reasons given for scientists' opposition to man-in-space are that it is costly, hazardous, and of relatively doubtful scientific value.

• **A waste of money**—Many scientists do not want science to be the scapegoat for what they believe will be an expensive experiment yielding very little. They claim that the money could be far better spent on more earthy projects.

For example, Dr. Vannevar Bush, a director of the Manhattan Project during World War II and therefore familiar with exotic and big-money research, says, "Suppose it would cost $1 billion to put a man on the moon. For the same money you could support a hundred research projects for 40 years. We need more basic research in physics, chemistry and biology. We need to finish the job of handling arthritis. We need to know more about the genetics of viruses."

Bush advises us to spend the money on projects such as these rather than on the present plan of "shooting it into space."

• **The "pro" view**—Many of those who want man to go into space for scientific reasons do not believe there's an "either-or" choice in spending the money—for instance, a choice between research seeking a cure of cancer or seeking the origin of the moon's craters. They say that in reality the choice would be between studying the moon or building B-70's or developing nuclear-powered aircraft or even constructing highways—that the money would never find its way into cancer research.

Moreover, they continue, by sending man into space we can move ahead in science and technology faster than by any other means, because we will have brand new environments to work with. It follows that where there are new environments there are also new and significant discoveries to be made.

At this point, a distinction is usually made between the work of unmanned probes and manned space craft.

An eager spokesman for manned space flight, Leo Steg, head of GE's Space Sciences Laboratory in Philadelphia, says that unmanned, measuring space probes should be sent to chart near space; but that the uncertainties of deep space call for intelligent beings rather than machines to do the exploring.

Steg points out that man is superior to machines in performing general experimentation, fabrication, maintenance, inspection, surveillance and piloting. Furthermore, he says, all these functions are basic to long-distance space flight to the moon and beyond.

On the other hand, the probe has the advantage in the areas of servo-function, sensing, and processes involving vigilance and speed, and perhaps even in decision-making.

Yet, Steg finds that man can outperform probes in the areas of manipulation combined with locomotion, pattern and object recognition, diagnosis and mode switching. Man also has the general attributes of self-programing, flexibility, adaptability and graceful degradation difficult to match with a machine.

• **The dismal science**—The problem can be looked at simply as one of economics. Speaking for this school, Rocketdyne scientist George P. Sutton told an aerospace medical meeting recently that man will be included in a space system if it is the most economical way to accomplish the mission.

He explained that ". . . system reliability must be improved or the flexibility of the mission must be sufficiently enhanced to make alternate ways of doing this mission without man considerably more expensive."

Observing that it is too early to reach a conclusion about extended future space operations, Sutton says that his personal feeling is that the number of missions that man will conduct as an operator will be relatively very few for the next 15 years. He gives the following reasons, several of which are being picked up by scientists who argue that man should not go into space now:

—For extended future manned space operations, we need a new big booster to give us the ability to carry the necessary payload for long-duration, long-

(Continued on pg. 38)

New Route to Cathay—Step by Step

Ralph S. Cooper of Los Alamos Scientific Laboratory has brought to the attention of the missile/space industry an interesting document.

The historic paper, with Mr. Cooper's comments, was reproduced in the form of an office memorandum on the subject of "Scientific Review Committees."

While it is well known that Columbus made a vain appeal to the senate of his native state of Genoa (as well as to the King of Portugal, to Henry III of England, and to the Dukes of Medina Sedonia and Medina Celi), it was not until very recently that the full official Genoan Senate reply came to light. It was discovered, along with other of his early documents and letters, in a monastery library in southeastern Spain and perhaps sheds some light upon why Spain rather than Italy was the dominant maritime and colonial power in the 16th century. A translation of the letter follows.

To : Cristobal Columbo
From: The Senate of Genoa

We the Senate of Genoa thank you, dear countryman, sea captain, geographer, and adventurer, for your presentation before us of an ambitious plan to open a new sea route to Cathay. Being most impressed, but untutored in the technical arts, we assembled a committee of the finest academic minds in our own and neighboring states to examine and review your proposal and make recommendations upon our course of action. We are most pleased with their intellectual insight and broad understanding of the problem.

Sig. Alfonso Chioggia, Physical Metaphysician, Genoa State University (GSU)

> "We must first study the oceans, their depths, temperatures, currents, tides, wind velocities, weather, and most particularly the recently discovered inner and outer dragon belts, and, of course, the effect of the edge of the world upon all the previous items."

Dr. Vittoria C. Vincenzo, Chairman, Department of Mechanical Arts, Venice Institute of Technology (VIT)

> "Vehicle and propulsion systems should be examined and the optimum selected for the mission. A careful comparison must be made of manned oar vs. sail propulsion and thought given to the development of advanced concepts such as might be based upon Hero's water vapour engine or Archimedes' screw. As for the vehicle itself, in addition to the many structural and hydrodynamic calculations, one must weigh the use of a single large ship against the suggested three of standard size."

Sig. Carlos Fiorento, Professor of Astrology and Occult Science, University of Genoa at La Spezia (UGLS)

> "One must develop techniques of astrogation, that is, selecting one's course by consultation with the stars and planets. Alternatively, one might consider using the newly developed lodestone, though this suffers from unreliability, inaccuracies, and is yet untested under the expected environmental conditions. Arrangements should be made for communication among the vehicles or with the base, and work proceed with flags, lanterns, mirrors, and notes in bottles."

Herr Dr. Franz von Schulte, Professor at Large, Medicine and Life Science, The University of Leipzig, visiting the Genoese Bureau of Research (Savona)

> "Such a voyage requires considerable advance in our understanding and controlling the various humours which afflict the human body and spirit. One obvious case is the prevention or cure of scurvy. In general, one must determine sound dietary regimens and devise techniques to provide for the sanitary necessities over long periods at sea. These range from obtaining fresh water from salt to concocting a variety of interesting fish recipes. This latter brings us closer to problems of the spiritual humour, involving long periods of loneliness and/or mal de mer with the possibility of group dynamic interactions leading to mutiny, for example."

The committee included representatives from the church (Msgr. Donella), the government (Minister De Stortzo), and the Bureau of Finance (Sig. Barrata). These eminent gentlemen discoursed at great length upon the theological and political aspects of such a project, and Sig. Barrata most wisely pointed out that one must compare the development and operational costs of this uncertain method of reaching Cathay with cost of improving the well-established Polo overland route. Indeed, he observed that one could pave the entire route with Florentine tile for the price of one round trip sea voyage. Nevertheless, these are prosperous times and the enthusiasm of the scientific members of the committee was undampened. Thus their recommendations were as follows:

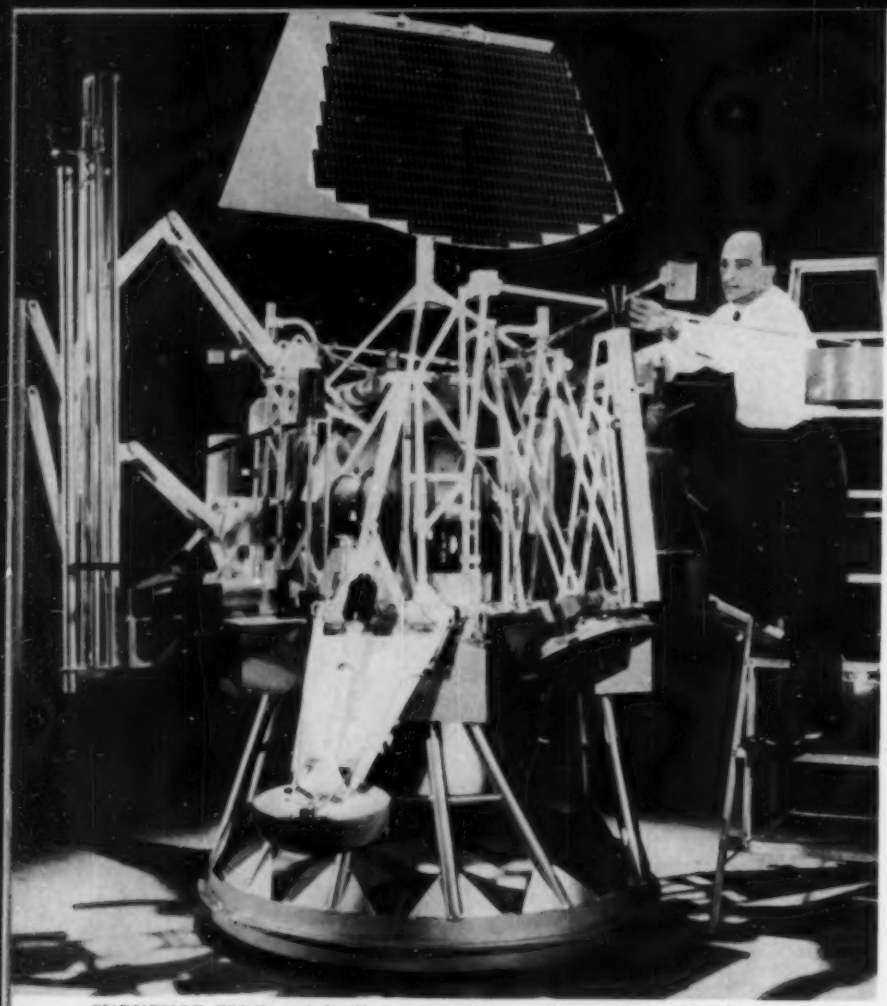
1. Study programs be initiated to solve the aforementioned problems.
2. When they are solved, a series of unmanned, instrumented vehicles be sent to Cathay, the final ones carrying animals and instructions for setting them upon the return route.
3. Finally, establish an academy for instructing captains in creative leadership (because, though you have conceived the trip, you are unikely to possess that exact mixture of attributes required for this demanding position) and for training crews in favorable dynamic group response.

We feel you will be quite pleased with the output of this progressive, forward looking committee of profound scholars. Incidentally, there was one additional member of the committee, a rather rash and impetuous young mechanical engineer, lately of Florence, who was sent in place of the ailing Dr. Taglatti of the University of Milan. Though he came highly recommended, he showed his immaturity and poor judgment by advocating the voyage itself be initiated immediately. Investigation proved him to be quite eccentric (he talks of flying machines and fancies himself an artist), and he was therefore dismissed from the committee. He is the illegitimate son of a Florentine notary and takes his name from the pace of his birth, Vinci, Leonardo being his given name, should you desire to contact him.

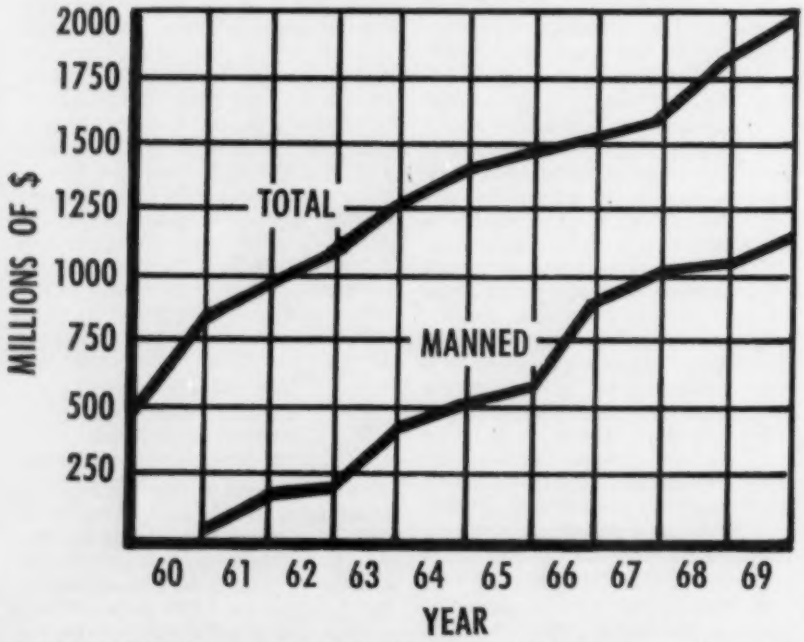
Most respectfuly yours,
Salvatore Paello
Secretary of the Senate
The Sovereign State of Genoa

Thus Columbus continued in his search for a sponsor until he was at last successful, at least in starting his voyage. It had been pointed out that the problem of trade with China (especially for Spain) is yet to be solved. Should another Columbus appear, what would we say to him?

Ralph S. Cooper



SURVEYOR 750-lb. soft-landing spacecraft, sometimes called a "mechanical octopus," will be crude substitute for man in early lunar exploration.



TOTAL MARKET for space payloads by 1970 will reach $2 billion, two-thirds of which will go for manned spacecraft, according to GE estimate.

(Continued from page 36)

distance missions.

—We need a lightweight nuclear-reactor-type power source which is shielded for manned space operations.

—We need experience in sustaining man in the hostile environment of space.

—We need a good microwave long-distance communications system.

—Furthermore, we need to know the results of many of the space programs now going on.

• **Man not ready for space**—One of the most outspoken critics of the course of science in the U.S. admits that we must use scientific achievement as a prime means for competing with the Soviet Union. However, Alvin M. Weinberg, director of Oak Ridge National Laboratory, asks whether the U.S. is wise in choosing manned flight into space as the primary event in these "Scientific Olympic Games." He objects to this policy on three grounds: hazard, expense and relevance.

Weinberg maintains that measurements of solar flare radiation, and perhaps of Van Allen belt radiation, are uncertain by a factor of ten (see p. 49). Furthermore, he says, various criteria now being used to calculate the thickness of radiation shielding may be considerably in error; and still further, the biological effects of the impingements of extremely energetic particles are not sufficiently understood.

Thus, although space is not clearly a forbidden land, it may be more hostile to human adventurers than it was believed to be five years ago.

Noting that we cannot really set the cost of a round trip to the moon, Weinberg says that ". . . the estimates of $20 billion to $40 billion for this mission are so large and cover so wide a range as to make the outsider doubt their validity on *a priori* grounds."

He cites the painful fact that bigness and high cost alone do not guarantee a project's success. For example, ten years ago leaders of the Lexington Project predicted that the nuclear-powered aircraft would cost $1 billion and take ten years to produce. The cost estimate was correct. But ten years later, no such airplane is flying.

Weinberg also warns against seeking after grandiose accomplishments which have little to do with the real issues of well-being. He points out that frequently in history the economic distortions caused by pursuing such goals have contributed to the decline of civilizations.

Nevertheless, it is clear that regardless of the debate man will be increasingly sent into space. It seems equally clear that the scientific reasons for sending him there may not be the most pressing ones. ⌗

Will they be heard?

Booster Ideas Are Big and Varied

Host of proposals is marked by spectacular claims by solid makers—combinations seen likely

by Frank G. McGuire

LOS ANGELES—If U.S. efforts to get man into space on a permanent basis rather than a hit-and-run basis should lag, it won't be for lack of ideas.

The current rash of booster proposals, concepts and combinations emanating from every propulsion company in the business recently prompted one harried recipient to mutter: "If paper could fly, we'd be so far ahead of the Russians, they'd go back to troikas!"

Despite the superabundance of ideas, however, there appears to be an uncomfortable feeling that this nation will do exactly what it did between 1955 and 1957—allow a perfectly capable launch system (in that case, *Jupiter-C*) to sit idle because nobody in authority will believe what it can do.

Rocketdyne says: "We had a 405,000-lb.-thrust liquid rocket system (the *Navaho* booster) around here for years, and nobody pushed it into our space program."

Thiokol says: "We've got *Minuteman* first-stage motors already produced that can put a U.S. manned vehicle into space with 1.2 million lbs. of thrust . . . But somebody will have to say 'Go!' "

Aerojet says: "This country has always underestimated what its industry can do in ten years, and overestimated what it could do immediately."

United Technology says: "Our biggest single deficiency is in large booster systems, and solid propellants could remedy this quickly if a go-ahead were given."

Almost without exception, propulsion engineers and their companies had similar comments on the U.S. future man-in-space program and the boosters it will almost certainly need.

• **Liquids vs. solids**—While liquid rocket proponents and many government officials dismiss solid-rocketry's claims as so much exaggerated wishful thinking, the solid-rocket advocates are chomping at the bit to get into the fray. They insist they can get large payloads into space cheaply and soon. Their major complaint is that "no one listens."

There may be a break in the offing.

In the eyes of presumably objective planners charged with advising the government on its future goals and systems for reaching these goals, the boosters of the next decade will very likely be combinations of liquids and solids, with the liquid stages uppermost.

Arguments for using solid rockets in the first, and possibly second, stages include economy, reliability, and the fact that maximum theoretical performance is not needed. Liquid rockets in upper stages will take advantage of highest possible performance with advanced propellants, where it counts most.

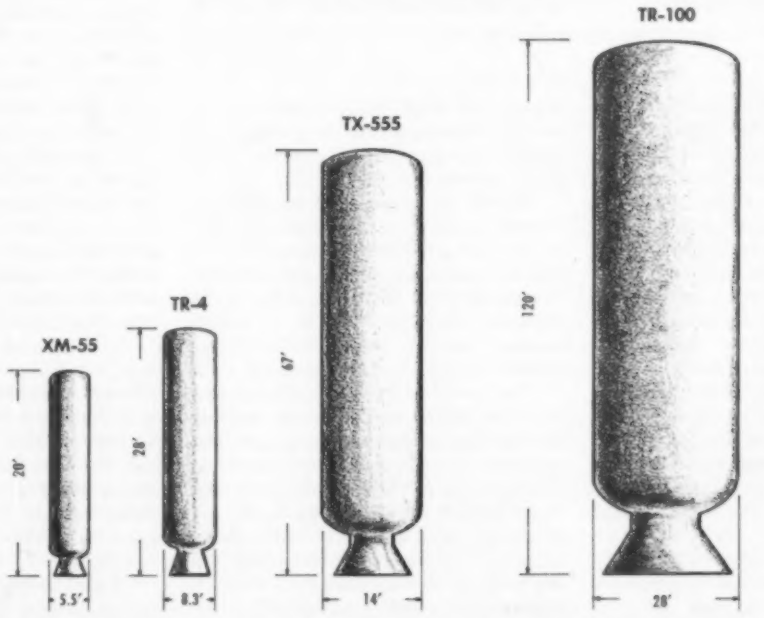
Nuclear rockets are seen only dimly—at a distance—for upper stages.

Electrical propulsion was described as "nothing to get operationally excited about until after 1970."

In citing advantages of liquids, Rocketdyne noted high performance, long duration, manned reliability, malfunction safety circuits, preflight checkout, hold down, clustering, recovery and re-use, cost. Simultaneously, the company named only manned reliability, clustering and cost as advantages enjoyed by solids when applied to large space boosters.

Solid propellant experts charged headlong into claims of high reliability for liquid boosters, saying such claimed statistical numbers as 99%+for liquid rocket reliability are interesting exercises in statistics, but just don't make sense when compared with the ratio of liquid-booster launches versus mission successes.

NASA interest in large solid boosters is high, despite the apparent disparity in a $68 million budget for liquid-fuel research and $3 million for solids. Maj. Gen. Don R. Ostrander, Director of Launch Vehicle Programs for NASA, said he would like to see about $15 million more devoted to



THIOKOL DESIGNS range from XM-55 Minuteman engine to 4.5 million-lb TR-100

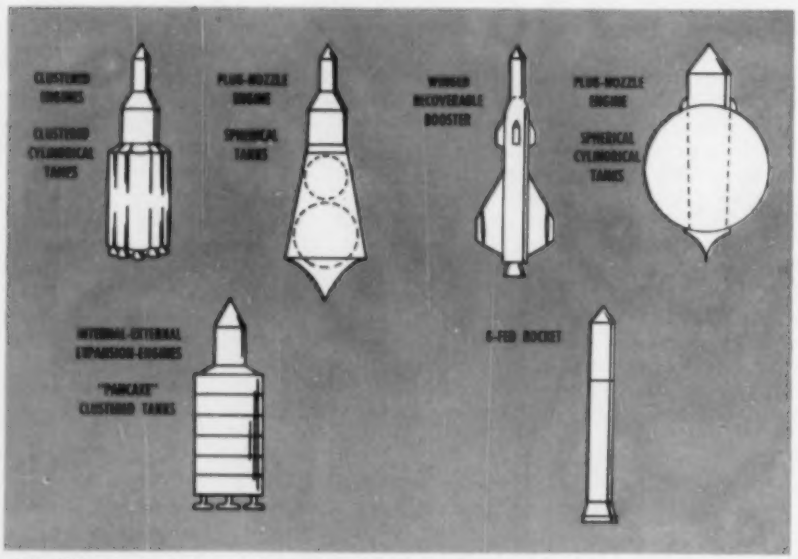
each type of propulsion research.

Whatever the outcome of the solid/liquid debate, reliability, cost and performance are interrelated. Sporadic crash programs will not improve all three simultaneously.

• **Present programs**—In the present situation, *Mercury* is the best known example of manned booster systems. Used alone, the *Atlas* will put the one-man capsule into a 120-mile-high orbit for a short period.

With *Agena-B* added as an upper stage, *Atlas* will put a three-man *Apollo* capsule in a 300-mile-high orbit for longer periods. *Saturn* could put the same capsule on a circumlunar trajectory, using the *S IV* and *S V (Centaur)* upper stages.

NASA hopes development of the *Atlas-Centaur* vehicle will give the U.S. a standard launch vehicle which will be the heavyweight workhorse until availability of *Saturn*, when it will still remain as a medium-size workhorse.



AEROJET study indicated these liquid configurations may be used in next 20 years.

Technical problems encountered with the *Centaur* vehicle, a two-engined design using liquid hydrogen and liquid oxygen, have caused NASA to postpone its initial flight test from mid-1961 to late 1961. The difficulty was in the hydrogen technologies involved.

One configuration which no one, especially the Air Force, wants to talk about is *Titan II* and *Centaur*. Both have a ten-foot diameter, and the combination would give the U.S. a capability to duplicate the Soviet Venus shot of February 12.

The Air Force has reportedly slacked off on *Titan II* information because of its big effort to "sell" *Minuteman* to Congress and the public. However, a space application for the *Titan II/Centaur* mating would bring many currently unattainable space goals within reach.

Many informed sources active in Air Force planning feel that *Titan II/Centaur* definitely has a place in a booster program, to fit between the capabilities of *Atlas* with upper stages, and the *Saturn* series.

Following the *Atlas Mercury* system, an *Atlas Agena-B* booster could put a minimum-mission two-man capsule into high orbit for two days or so. A *Titan II/Centaur* booster would put the same capsule into a higher orbit, or a better-equipped capsule into the same orbit for a longer time.

A very tight rein is being held on details of the *Titan II/Centaur* capabilities, but basic orbital missions can be speculated upon with available information. *Atlas Centaur* reportedly can put 8500 lbs. into orbit.

Based on unofficial guesstimates, *Titan II/Centaur* seems capable of placing at least 15,000 lbs. into a nominal 300-mile orbit. Considering the 2400-lb. weight of the *Mercury* capsule, the potential usefulness of a 15,000-lb. manned satellite appears worth the booster vehicle development.

The weight of a vehicle increases, according to the rule of thumb, with the increase in sophistication of re-entry methods. Air Force requirement for a 30-50,000-lb. payload for the *Aerospace Plane* project probably reflects this rule of thumb, and it is conceivable that a *Titan II/Centaur* payload would also use much of its added weight for a more sophisticated re-entry technique.

The same guesstimates give *Titan II/Centaur* a 2500-lb.-plus payload weight capability for escape velocities, versus the 1450-lb. capability of *Atlas Centaur* vehicles. A major reason for the added weight-lifting ability of the three-stage *Titan II/Centaur* is the considerable first-stage thrust increase over both *Atlas* and *Titan I*—namely, over 500,000 lbs.—plus the high impulse of *Centaur's* LOX/hydrogen propellants.

Although the *Saturn* program has been one of the major U.S. hopes in the booster race, there is a possibility—though not a probability—that it can be uprated even further by replacing the four center H-1 engines with a single F-1 engine. This change, including Rocketdyne H-2 engines rated at well over 200,000 lbs. thrust instead of the H-1's 188,000 lbs., would make the *Saturn* a 2.5-million-lb.-thrust vehicle. The single F-1 would be either fixed or gimballed.

Rocketdyne officials doubt that the step will be taken, but they say it is one of many being considered as an intermediate measure to the mythical *Nova* vehicle—which exists only as a concept to be powered by the F-1.

Rocketdyne says it will begin testing the complete F-1 assembly this summer, instead of the previously reported April, 1961, firings. The company expects to finish the PFRT (preliminary flight rating tests) by October of next year, and qualifying tests will man-rate it for use. Manned crews could use the powerplant anytime in 1963, a company official said.

Paul R. Vogt, Chief Engineer of Liquid Propulsion Operations at the North American Aviation division, said Rocketdyne will not use the F-1 in a single-engined application, unless NASA changes current planning. Many of the F-1's features, Vogt said, were developed with the never-flown E-1 engine of 400,000 lbs. thrust, product of a study program. He added that some of the tests even used E-1 parts.

Vogt also said Rocketdyne is working on an idea for using its J-2 LOX/hydrogen engine as a first stage, in addition to its normal upper-stage application for *Saturn*. Appropriate modification of the engine would adapt it to sea-level operation, possibly for a single-stage-to-orbit mission.

A cluster of J-2 engines, each developing 200,000 lbs. of thrust, is a "distinct possibility" for the future, Vogt said. No more than eight engines in such a cluster would be expected, he added, and he indicated possible use of an F-1 as an upper stage for such a high-impulse booster. The F-1 would, in this case, be modified from its present 14:1 nozzle ratio.

Commenting on the liquid/solid rocket debate, Vogt said: "Most major jobs in the future will be done by liquid

rockets, while solids will retain their role in lower performance applications such as the *Mercury* escape system and retro rockets. That's the way things have been, and that's the way they will remain."

"Solid rockets will be able to improve their mass fractions only by the development of new materials," he added, "but these new materials will also apply to liquids, so there will be no ultimate change in relative performance, since mass fraction advantages are now with liquids. Solid-rocket boosters are currently 30% heavier than liquids for a comparable mission."

While going along with the liquid rocket's claim to higher performance, solid-rocket producers were inclined to give it little else—especially when manned applications were considered—and even predicted the gap would close.

Aerojet's Dr. E. R. Roberts sees solid propellants with specific impulse values of 265 seconds, capable of obtaining theoretical burnout velocities of 25,600 ft./sec. He said this would represent a 44.5% improvement over the most advanced versions of solid rockets now under development.

• **No breakthrough**—These improvements, predicted for 1965 or sooner, are expected to result from the natural growth potential of presently used materials and techniques, rather than a technological breakthrough.

The company feels that the polyurethane propellants slated for the large segmented boosters have been thoroughly proven in *Polaris, Skybolt,* and *Minuteman* second stage, and that quality control and inspection procedures are already established.

Aerojet says none of the presently considered future high-impulse propellants promises to be cheap enough for first-stage application, and that the polyurethanes will do the job more cheaply. With this in mind, the company feels 2½ to 3 million lbs. thrust is the maximum to be expected of a 140-in.-diameter solid booster. Clustering would be resorted to for larger thrust demands.

Thiokol's approach to the large solid booster situation is that of on-site-loaded solid-propellant motors, but only after the country has adequately exploited what it now has available—namely, *Minuteman* first-stage engines.

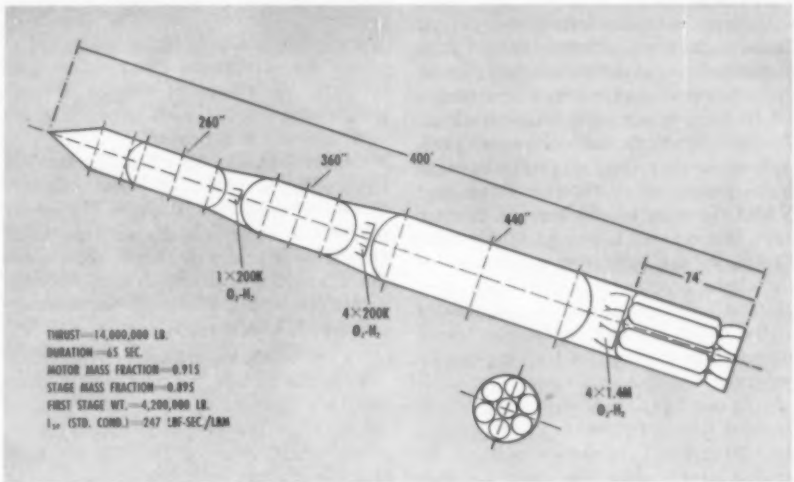
What's more, Thiokol says, the first flight test of a cluster of seven first-stage *Minuteman* engines (XM-55) can be conducted at Cape Canaveral within nine months from date project initiation.

The company has thoroughly researched the proposed vehicle and has no doubt concerning its feasibility.

The XM-55, clustered in a seven-motor first stage, would be used with a *Titan II* as upper stages to place a total of 25,000 lbs. into orbit. The XM-55's estimated ten million-lb./sec. total impulse would thus give a 1.2-million-lb. total thrust level to the cluster, and *Titan II's* engines would add well over 500,000 lbs. thrust after separation.

Thiokol believes the XM-55 has proven itself reliable, and that its status as a production item eliminates further development costs. In addition, the company says, the engine's structural strength allows clustering simply and cheaply; facilities and equipment for handling already exist; and properly clustered motors could place in orbit three times the weight now possible with existing systems.

Between 3700 and 25,000 lbs. can be put in orbit at costs as low as $178 per lb., the firm says, and 1000 to 7000 lbs. can be accelerated to escape velocities at costs of $559 per lb. by using the clustered XM-55.



HUGE VEHICLE seen by Aerojet would combine solid booster, liquid upper stages.

In addition to this configuration using *Minuteman* first-stage engines and a modified *Titan II*, Thiokol has a number of designs for large solid boosters to be used for manned vehicles.

A solid-propellant "TR-4" design using the segmented approach could be used for those applications beyond the ability of the XM-55, the firm says. This design is predicated on a single-segment engine of about 70,000 lbs. gross weight, which, when coupled with another similar segment, could orbit 10,000 to 70,000 lbs. Orbital capability could also be achieved, Thiokol says, by using an unsegmented engine of approximately 110,000 lbs. gross weight with liquid upper stages.

Following the TR-4 is a TX-555 design to provide for manned lunar landings with return capabilities. Used singly as a first stage, the TX-555 would put 48,000 lbs. in a 300-mile earth orbit. A cluster of seven such engines would, when used with three TX-555's as a second stage and liquid rockets for third and fourth stages, place 320,000 lbs. into orbit.

Costs per pound of payload for the mission would be $119.00.

The granddaddy of the Thiokol designs is the TR-100 engine, with a gross weight of 4.5 million lbs. Used singly as a first stage, the TR-100 would orbit 300,000 lbs. when selected liquid rockets form the upper stages.

Regarding its loading techniques, Thiokol says the possibility of having a useless rocket on a pad due to poor propellant quality is slight. The company pointed out that a five-foot-diameter void could be tolerated in the propellant in a large on-site-loaded solid booster with only a ten psi change in chamber pressure—not enough to cause trouble.

United Technology Corp. is due to begin test firings of its conical segmented engine, the S-1, this summer, with a view toward supplying NASA with the design for solid boosters in future manned programs. The S-1, a single-segment motor generating 250,000 lbs. thrust, will provide a basic booster which could be used with a number of existing upper stages as a workhorse vehicle. UTC has run calculations on using the S-1 with the second and third *Minuteman* stages, and both *Polaris* stages for orbiting 1000-2000 lbs.

UTC says it can produce the S-1 at the rate of two per week, and the question of higher production rates will be faced when necessary.

The company says about twenty S-1 flight-weight motors would undergo tests in a PFRT program.

UTC feels the conical segmented design will eliminate the erosive burning problem, and give other advantages to a solid booster. ■

Duplication seen . . .

Spacecraft Plans Are Still Cloudy

Both Apollo and Dyna-Soar are pushed, but decision on scientific vs. military emphasis is yet to come—Aerospace Plane is factor

FUMBLING policymakers once again appear to be letting the United States drift down a double garden path of confusion and diffusion—this time in the development of manned spacecraft.

In the absence of a clear-cut objective, the Kennedy Administration presently is encouraging duplicate man-in-space programs by the Air Force and NASA—neither of which seems to offer any immediate hope of overtaking Russia in the race for the moon or elsewhere.

The situation today is reminiscent of the confusion and duplication which attended the birth of the U.S. big-missile programs a half-dozen years ago.

On one hand, NASA is preparing to proceed with a follow-on to *Mercury*—the three-man *Apollo*—which is intended to 1) orbit the earth for two weeks in the 1965-66 time period; 2) perform a circumlunar flight two years later; and 3) land on the moon in 1969-70. (Some NASA officials believe that if *Apollo* is turned into a crash program, the lunar landing possibly could be speeded up to 1967.)

On the other hand, the Air Force is proceeding with *Dyna-Soar*—a one-man glider—which is supposed to make its first suborbital flight in 1963-64, and *Dyna-Soar II*, which is to make its first orbital flight in 1964-65, providing the program receives sufficient funding. The Air Force also has in its pocket proposals for *Aerospace Plane*—aimed at creating an air-space weapon system somewhere about 1970, depending on how urgently it is pushed.

Moreover, the Air Force has funded studies for a series of other manned craft—orbiting space stations, *Slomar* (a shuttle for logistics and maintenance of orbital craft) and manned reconnaissance vehicles—which, if they become programs, would effectively duplicate or overlap NASA's plans for *Apollo*.

• **Scientific vs. military**—When they are set side by side, the proposed civilian program appears to be a less versatile duplicate of the proposed military program. There seems to be little question that the military program could provide the hardware needed for scientifiic research. There is considerable doubt whether the civilian program could provide the hardware needed by the military.

The outstanding technical difference between the programs is that *Apollo* will have a *Mercury*-like ballistic-parachute configuration, while the *Dyna-Soar* and *Aerospace Plane* vehicles are to be winged.

NASA's *Apollo* is conceived strictly for scientific exploration in testament to the "peaceful" approach of the U.S. man-in-space effort. But as of the moment, strangely enough, *Dyna-Soar* also fits into the strictly "scientific" category. For it is classified as a R&D project only—a project which "could lead" to an orbital-bombing weapon system. If not, to merely a winged version of *Apollo*.

At present, there is perhaps some question whether it is easier to realize a ballistic craft than one with wings—particularly for entry to the atmosphere after cislunar flight. There are significant advantages and disadvantages to both approaches.

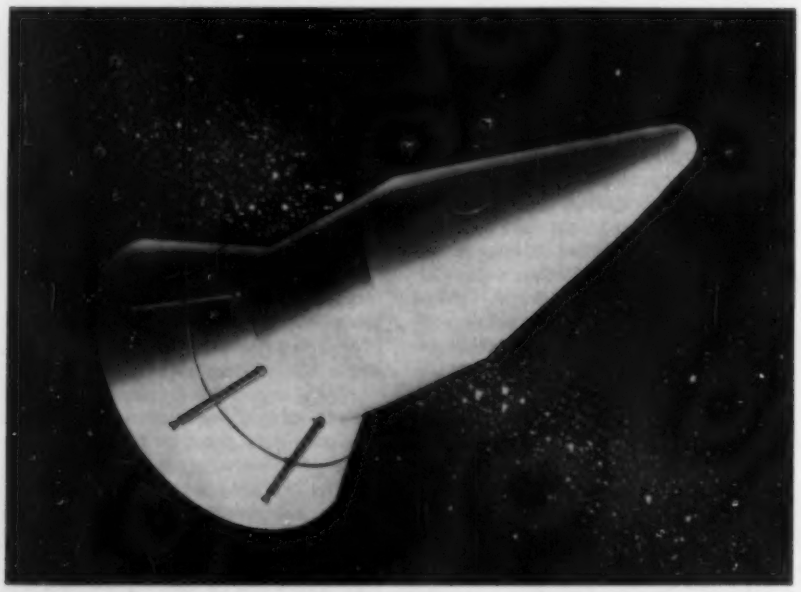
But these must be weighed against what the two systems should be expected to accomplish. Is the mission really to be strictly scientific, or is it in actuality military in nature? The evidence is that the threat in space is military; that this is the underlying reason for speeding up the man in space effort.

If the objective is military, is *Apollo* the best path to follow? Can it be converted readily into a weapon system? Or should the other avenue represented by *Aerospace Plane* be pursued overtly from the start?

These questions are at the heart of the current U.S. space policy muddle. They become even more difficult when examined in the light of whether the country has the ability to produce simultaneously *Apollo*, *Dyna-Soar* and *Aerospace Plane*—and still catch the Russians. Each is a multibillion-dollar project. Each must draw on the same reservoir of technical skill and industrial capability.

The danger of diluting the space program seems quite apparent when the Soviets are pursuing only one path, and they are ahead.

• **Aerospace Plane starting**—Although the Kennedy Administration is giving every indication of placing its lunar landing bets on *Apollo*, it may



APOLLO SPACECRAFT concept by GE includes abort rockets (visible on sides). Three-man capsule would be located in cylindrical mid-section of 15-ft. vehicle.

hedge them somewhat with *Aerospace Plane (ASP)*.

The Air Force is understood to be pushing for a FY '62 downpayment of $30 million to get *ASP* moving. Some work already has been done out of applied research funds—enough so that the Air Force hopes to move more into the feasibility-study-contract stage in July. Major companies in the competition include Boeing Co., Convair-Astronautics, Douglas Aircraft Co., Lockheed Aircraft Corp., and Republic Aircraft Corp. They are heading up sizable industry teams (Convair, for example, is teamed with Marquardt Corp., the Rocketdyne Division of North American Aviation Corp. and Garrett Corp.).

Marquardt is believed to have spent some $10 million on development of a liquid air cycle engine under Air Force sponsorship for *ASP* application (M/R, May 22, p. 14) and General Electric Co. and Pratt & Whitney are also reported to be working on engines for the spacecraft.

Overall cost of bringing *ASP* to operational status is estimated at $3-$5 billion by 1970. A crash program might advance the date. But this seems unlikely, unless President Kennedy decides to expand the military role in space materially.

General specifications for *ASP* call for a craft which can take off from existing B-52 runways, accelerate to orbital speeds, rendezvous with space stations and return to the takeoff field for landing. It would thus provide the means for ferrying men and materials into space for construction of a spacecraft to be launched from orbit. Ultimate versions might make the *ASP* capable of earth-to-lunar missions alone.

Maj. Gen. O. J. Ritland, chief of the Air Force Systems Command Ballistic Missile Command, said recently there is no technical reason why *ASP* could not perform earth-to-orbit missions. He indicated no breakthroughs would be required. Marquardt likewise contends no major breakthroughs are needed in the engine area.

Presumably engines for *ASP* would be hybrid rocket-ramjet with the craft taking off on rocket power and accelerating to hypersonic speeds where the ramjets would take over. Under Marquardt's concept, the craft would then orbit through the earth's atmosphere, scooping up oxygen which would be liquified with the help of an in-board supply of liquid hydrogen and stored in tanks. Since this process would occur after takeoff, gross takeoff weight could be minimized.

On leaving the atmosphere for space, *ASP* would then revert to LOX-LH_2 powered rocket.

• **Dyna-Soar—bigger potential?**—*ASP* would be an outgrowth of the rocket-boosted *Dyna-Soar* glider. There is a question of how superior it would be to *Dyna-Soar* if the latter was designed in later models for in-board propulsion.

DYNA-SOAR, shown in artist's drawing atop Titan II, is to weigh about 5 tons.

Not much has been said about the potential of *Dyna-Soar*. Engineering details also are skimpy. *ASP* represents Air Force hopes for a one-unit spacecraft, eliminating boosters and having the advantage of a powered landing.

But *Dyna-Soar* is the only solidly-funded spacecraft beyond *Mercury* and it is the first U.S. attempt at putting wings on a spacecraft.

The possibility of *Dyna-Soar* becoming a rendezvous vehicle is apparent. Martin Co.'s concept of *Slomar* closely resembles configurations advanced for *Dyna-Soar*. The main difference is in *Slomar's* capacity for carrying five men, against *Dyna-Soar's* one.

This has important ramifications in the technique to be employed in accomplishing a moon mission. It also points up another area of potential overlap with *Apollo*, which also is being designed for orbital rendezvous.

Insufficient booster capacity probably will make it necessary to use an orbital launch for a flight to the moon. *Apollo* would need orbital refueling for a lunar landing and return, and although it has not disclosed any plans in this direction, presumably any lunar craft proposed by the Air Force would, too.

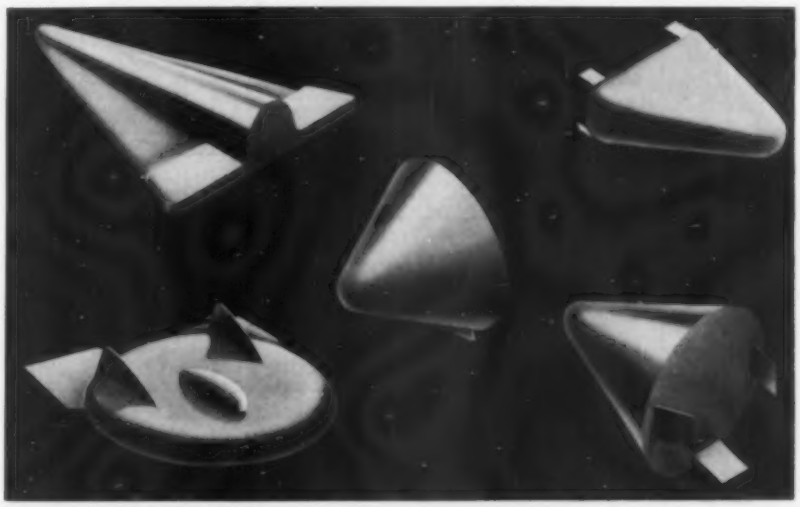
Dyna-Soar is expected to weigh in the neighborhood of about 10,000 lbs. —approximately 8000 lbs. for airframe and some 2000 lbs. for wings and supporting structure in its early configuration. The three-man *Apollo* would weigh 12,500 lbs., giving it a considerable weight advantage.

Designs made available by the Air Force show *Dyna-Soar* to be basically a single delta wing with a pair of vertical stabilizers at the outer edges. It will be about 35 ft. long and have a wingspan of about 20 ft.

• **Mating problems**—NASA's spacecraft specialists have calculated that the addition of glider-like wings to a reentry vehicle adds at least 30% to the weight. Besides the weight penalty, the winged vehicle develops serious problems of aerodynamic stability on the upward flight.

The Air Force already has decided that the *Titan* must sprout fins to take care of the stability problem. The *Saturn* will also have fins if it is used to propel the *Dyna-Soar* into orbit.

(Continued on page 106)



FIVE ORIGINAL PROPOSALS for Apollo configuration have reportedly been narrowed down to three at center and right. Weight penalties caused rejection of others.

Soviets went all-out . . .

Life Scientists Demand Top Priority

Experts warn that long-term manned missions can only be undertaken after much more is known—no program exists

by Heather M. David

MAN, MOST IMPORTANT aspect of man-in-space, may be getting short-changed by an inadequate, directionless support effort.

In general, the problems are known. The medical profession knows what a man needs to stay alive; psychologists need a thorough knowledge of how much he can be asked to adjust and still live effectively.

Some compromises will have to be made. "Adjust," a true 20th century slogan, will be the byword of the spaceman of the decade. And for this we need a thorough knowledge of how much he can be asked to adjust and still live effectively.

There's a great deal to be done. Some of it can be done in ground laboratories. But as Dr. Robert S. Pogrund of the Aerospace Corp. told M/R: "What is needed is an assignment of highest priority to the biomedical space effort. We need well-controlled and well-designed biomedical experiments that produce clear-cut, interpretable results, in lieu of the previously designed piggy-back type of experiment."

No one can expect a man to go blithely off into the blue where not even an animal has been. And one or two monkeys and a handful of mice who got a free ride because someone wanted to test a missile or a camera are not enough.

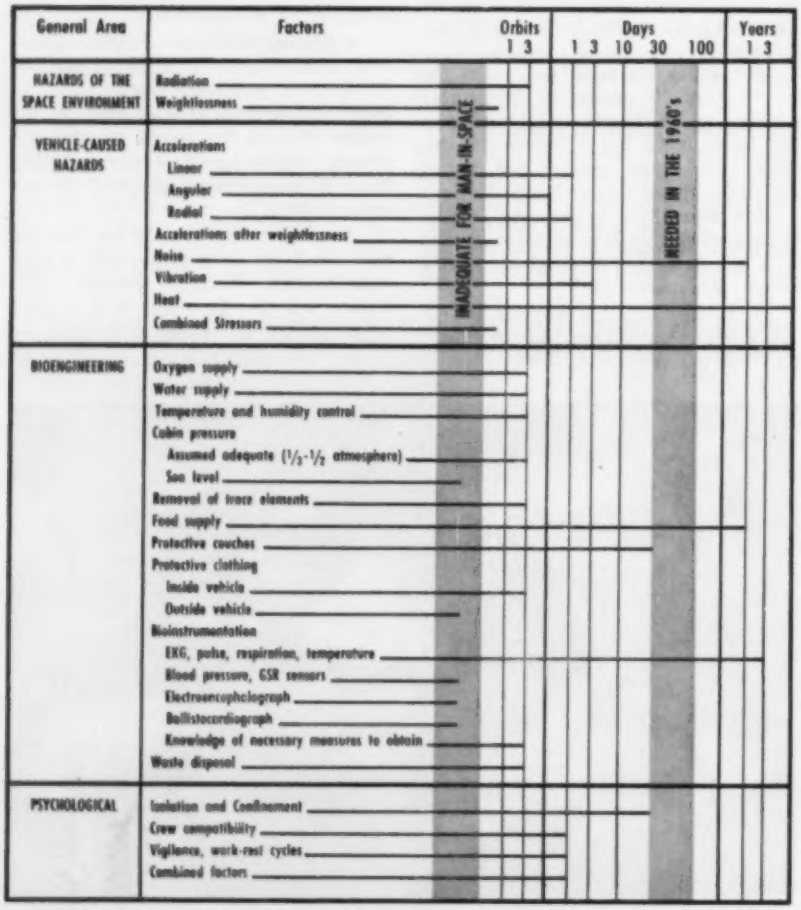
• **Contrast in effort**—The Russians apparently saw this several years ago. The whole story of the Soviet space program is a straight line of biomedical flights. They built on each one, added information, and ended with a superior system containing a man. Apparently before 1957, a top-level decision was made that the national goal was a man in space. A realistic, all-out effort was made to attain it.

In America, it has so far been a different story. One U.S. life sciences expert recently said: "There is no existing program in the United States that aims at solving the future problems of manned space flight."

The present U.S. manned spaceflight schedule calls for *Mercury* orbital flights in late 1961 and 1962. The next announced step is an *Apollo* vehicle which might begin orbital flights in 1966 or 1967. The National Aeronautics and Space Administration has not announced any interim program beyond some orbital shots with chimpanzees in *Mercury* capsules.

A lot of space medicine people are warning that it may be foolhardy to construct a vehicle such as *Apollo* for long-term missions without first finding out exactly what is needed. These are the problems—puzzles which can't be solved in simulators, computers or by extrapolating from a few hours' experience:

—Longterm weightlessness—whether or not to design the ship to provide artificial g. "Let's not be caught in 1970 with all our money on one horse and



CURRENT STATE OF KNOWLEDGE chart compiled by M/R shows that the United States must close some serious gaps in order to attain goals it has set for the decade.

TRUE WEIGHTLESSNESS in an AF C-131 unfortunately last only half-minute, is preceded by a 2½-g dive plane must make to prepare for ballistic trajectory.

SHAKING experience tests subject's reactions during vertical accelerations.

find out it can't run the distance," critics say.

—Radiation—not what it measures on an emulsion pack or pieces of tissue, but what does it do to a whole animal?

—Spaceflight itself—there's literally no way on earth to combine all the physical stresses—even those caused by the vehicle alone. And there's no way to simulate the sheer terror that might afflict a space traveler.

The *Mercury* capsule is not considered particularly adaptable for use as an experimental animal space laboratory. Its life support system cannot be extended to supply oxygen, food and water for more than about two days without installing a completely different type of system. Only enough hydrogen peroxide for attitude control can be carried for a short mission.

The *X-15* and *Dyna-Soar* simply won't fly long enough.

The Air Force has proposed a bio-astronautical orbiting satellite system *(BOSS)* to orbit a 40-50 lb. chimpanzee for several weeks. Lockheed Aircraft has designed a mockup capsule which could be flown on an *Agena B*. The Garrett Corp. has engineered a very promising life support system which was shown at the Aerospace Medical Association's recent meeting in Chicago. But the program remains in limbo for lack of funds.

Col. Charles H. Roadman, acting director of life sciences at NASA, also admitted that an interim program of some sort would be necessary. But so far no one has gotten a franchise.

• **Experts restless**—Some harsh comments are being made in industry circles about the situation.

A spokesman for the Garrett Corp., recognized authorities on life support systems, told M/R: "Insufficient emphasis has so far been placed on the requirements of human occupancy for long-duration voyages."

He suggested, "A central government agency should be established to direct the life sciences and environmental control systems activities on the basis of national policy and objectives, with all of the various services facilities participating in combined complementing operations."

The Northrop Corp.: "A satisfactory approach to development of life support equipment has not been taken and indications are that, at present, this work lags badly."

The head of life sciences engineering department of one of the largest companies in the spacecraft business said: "The lead times for life support systems are much longer than for other systems and the present lack of effort is really going to hurt."

He added, "the amount of money budgeted for the life sciences does not reflect the stated objectives of the country."

At the Aerospace Medical Association meeting this year, there even was a movement to pass a resolution urging that "every available and competent scientist devote his full energies to solving problems involving manned spaceflight." Although the resolution was not acted on, the problem was recognized.

There's no lack of people who'd like to do the job. An estimate of the in-house effort in industry would have to run in the millions of dollars. There is considerable enthusiasm in all branches of the services for space medicine or life science projects.

The situation is producing some unnecessary duplication, which the Garrett Corp. terms "unnecessary, inefficient and uneconomical." Says Spacelabs vice president Jim Reeves, "This will continue until mission definition and assignment of responsibility have been carried out."

• **Radiation**—Urgently needed is a series of animal probes. These should be sent to different altitudes and orbited for varying lengths of time. Also, each experiment will have to be repeated to get data for both years of maximum and minimum solar activity. (See Special Report: Radiation, p. 49).

• **Weightlessness**—The question is "how long?"

U.S. space medicine experts suspect that weightlessness' effects can be divided into three categories: 1) short-term flight, up to three orbits—no problem. 2) flights lasting more than about six hours—some muscle debilitation which can be corrected with exercise. 3) flights longer than perhaps 10 days or two weeks—may require rotating the ship to provide artificial g.

The third point poses the challenge. When will it become necessary to rotate the ship? A good way to find the exact breaking point would be to perfect an animal satellite which could be orbited for a week or weeks at a time.

Current experience in weightlessness is practically nil: U.S.: Alan Shepard 5 minutes, *MR-3*. Major Robert White, 2 minutes, *X-15*. The *X-15* is capable of about 4 or 5 minutes by flying in a ballistic trajectory, the KC-135 about one minute, the C-131 half a minute.

The Soviets say that weightlessness during Gagarin's one-orbit flight had absolutely no effect on him. No scientific results have ever been published on

the Russian dogs which were weightless for a day or so in *Sputniks II, V, VI and VIII.*

There are two methods of simulating weightlessness, neither completely satisfactory. Suspension in water can produce some of the effects of muscle disuse and lack of stimuli. The Air Force's Aeromedical Laboratory is studying these effects at Wright-Patterson AFB (M/R, May 22, p. 36).

Chance Vought Astronautics has constructed an air jet-supported platform which attains a near-frictionless state. A man on the device has some of the same difficulties of moving about and functioning as in a weightless condition. Vought is using it to design tools for use in space vehicles.

Some extrapolations from ballistic trajectory flights may be useful if very-short-life animals are flown. Chance Vought has an Air Force contract to make cine-microscopic observation of amoeba launched into ballistic trajectories. General Electric's J. J. Konikoff has also suggested studying the interaction of enzymes in the short-term weightlessness, but the studies are mostly in the theoretical stage.

• **Accelerations**—*Mercury MR—3* proved that an astronaut could easily withstand the g forces of normal launch and re-entry. In fact, much higher stresses have been withstood in centrifuges and rocket sleds.

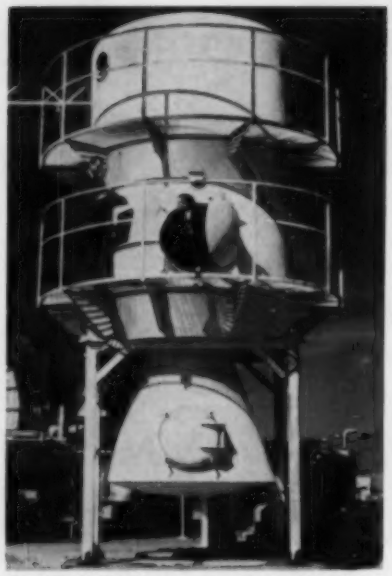
At one time a number of people had suggested that an astronaut could survive g forces better if he travelled in a "space bathtub." This idea has largely been dropped because of experiments on both the Navy's Johnsville and the Air Force's AML centrifuges. The men could move their arms and legs better, but trapped air in their lungs and around their hearts caused pain. Chimps given more g's died because of the trapped air.

Actually, the real problems are not in a normal trip but in impact and escape. Not much is known about how violent an impact a human can survive and how best to protect him. Physiologists at General Electric MSVD are literally "dropping mice" in the hopes of extrapolating some of the tolerance data (M/R, April 17, p. 35).

A Dayton firm, Technology, Inc., is delivering a vertical deceleration tower to the Aerospace Medical Lab at Wright-Patterson which should help fill in some of the gaps.

Emergency escape may be a pretty horrible experience. The pilot would be buffeted about, getting high g's from all different directions in succession.

Dr. Harold J. von Beckh, an Austrian scientist now at the Aeromedical Field Laboratory at Holloman AFB, has formulated what he calls "multi-



CONVAIR'S "space station" will duplicate space heat, isolation and vacuum.

TEXAS INSTRUMENTS' Mercury telemetry transmits data on pilot's condition.

directional g protection." The escape capsule would turn automatically—and quickly—so the pilot would always get the g in a transverse direction. He'd probably be a very sick boy but he'd have a better chance of staying alive.

Norair Division of the Northrop Corp. has designed a simulator especially for tumbling and spinning. (see cut, p. 73). The 10-ft. sphere will rotate on three axes up to 70 rpm—a real torture device. The School of Aviation Medicine will use it to investigate restraint systems and body positioning.

• **Heat, noise and vibration**—A very important study on thermal and atmospheric controls for space vehicles is being conducted by North American Aviation under a three-year, $1.5-million contract. Garrett's AiResearch division holds a $300,000 subcontract for the manned capsule portion. Results will undoubtedly influence future systems.

Doctors know a lot about how much heat, noise and vibration a man can stand. Much more simulator work is needed in combined stresses such as vibration + heat + noise, or better still vibration + heat + noise + acceleration. Dr. A. H. Schwichtenberg, Lovelace Foundation's Aerospace Medicine chief, said "We need a rocket sled 150 miles long—not just 7 miles."

A simulator being built for the Air Force by Garrett can combine low pressure, heat, noise and isolation, and can be placed on a centrifuge. Norair's rotational simulator also has temperature and pressure controls.

• **Bioengineering**—As the U.S. projects its goals to longer missions, it becomes more and more essential that a flight-worthy regenerative oxygen and water system be developed.

Exotic plant systems will probably remain in the textbooks until well into the 1970's. The early spaceman will get his oxygen from a chemical CO_2 cracking system or through electrolysis of water.

Space medicine experts evaluating reports of the Gagarin flight say that the Russians already have a superoxide regenerative oxygen system. An endless supply of oxygen could mean an astronaut's life if his re-entry system failed. Orbital decay would eventually bring him down, and he might live the extra week or so without food—but not without oxygen.

Also needed in the next few years is a regenerative water supply. General Electric has succeeded in reclaiming potable water from urine at a relatively low weight and power cost. The apparatus is now being tested at the Navy's Air Crew Equipment Laboratory.

Trace elements not even thought about on earth could be very dangerous in a few square feet of enclosed air. A number of laboratories are now investigating man's tolerance to minute amounts of these elements.

Bechman Instruments is developing a gas chromatograph which will be used on future NASA programs.

• **Cabin pressurization**—Man's natural environment is a two-gas atmosphere at near sea-level pressure. The best the U.S. has been able to provide for its space capsules is a one-gas system —100% oxygen at about ⅓ sea level pressure. Although this may be perfectly satisfactory for the *Mercury* astronaut, bioastronautics experts warn that it may be dangerous to ask a man to adjust too long.

A real breakthrough needed in the 1960's is the engineering of a two-gas system attaining sea-level pressure. Sophisticated sensors will be needed to sense each gas separately and maintain the proper balance. At the same time,

(Continued on page 92)

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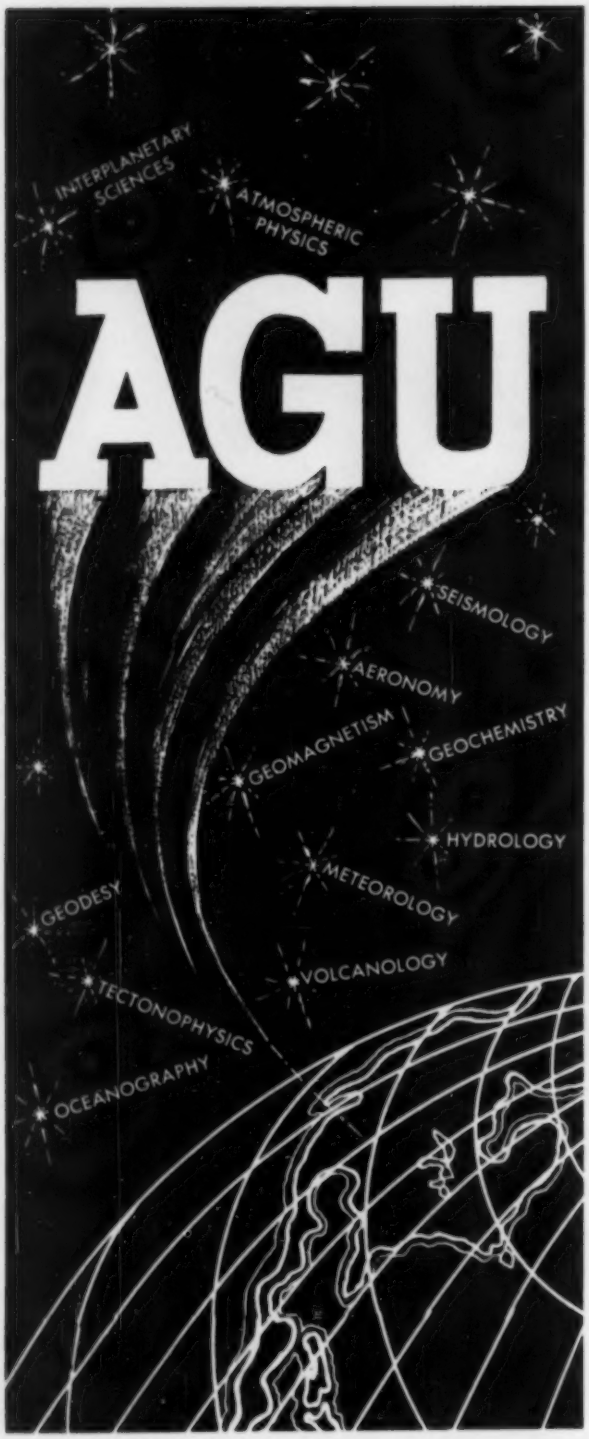

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Radiation Hazard Is Top Flight Problem

Little is yet known of how man and materials will wear under exposure—solar flare measurements highly unsure

by John F. Judge

THE LARGEST single problem facing man-in-space originates with the oldest body in our solar system—the sun.

As recently as 1958, radiation in space was thought to be negligible. In May of that year, Van Allen announced the discovery of the great radiation belts around the earth. Closely after this came the discovery of the solar proton beams or solar cosmic rays. Radiation then became a major factor affecting spacecraft configurations and weights, and the choice of trajectories.

Little is actually known, even now, about the nature of space radiation, although a great deal of data has been published in the past three years. But the ionizing radiation a vehicle encounters in space is known to consist of at least three types—cosmic, trapped and solar flare.

Cosmic radiation is currently thought to be of minor importance to structural designers. The dosage is expected to be quite small, and, in any event, cosmic rays comprise atomic nuclei traveling with such extreme velocities—corresponding to energies in the bev region—that no foreseeable shielding will stop them.

The best that can be hoped for is that passage through the vehicle will produce a minimum background dose level.

H. E. Newell and J. E. Naugle of NASA say one aspect of cosmic radiation has not been entirely evaluated. While the overall integrated dose is very small, a very intense exposure is given to a very small amount of material along the track of the individual particle as it stops. Experiments with high-altitude and -latitude balloon flights are continuing

A recent Air Force state-of-the-art report says that cosmic radiation is composed of about 79% protons, 20% alpha particles, 0.78% carbon, nitrogen and oxygen nuclei and 0.22% nuclei with atomic number greater than 10.

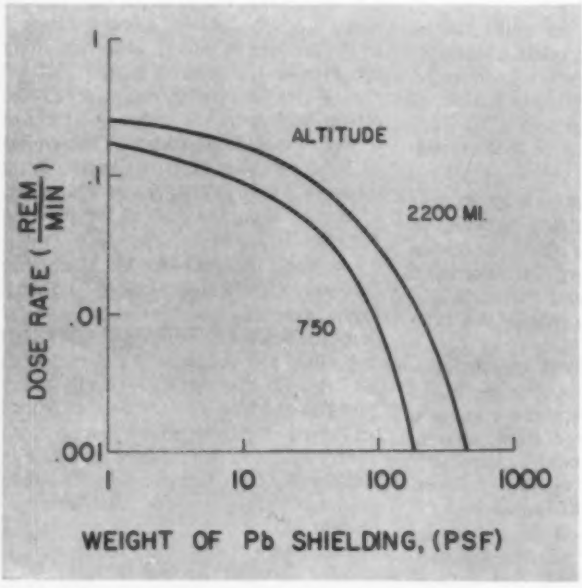
In addition to the particulate component, there are very-high-energy gamma rays. The total effect of passage through a material is secondary radiation composed of electrons, protons, neutrons, mesons and a variety of "strange" particles.

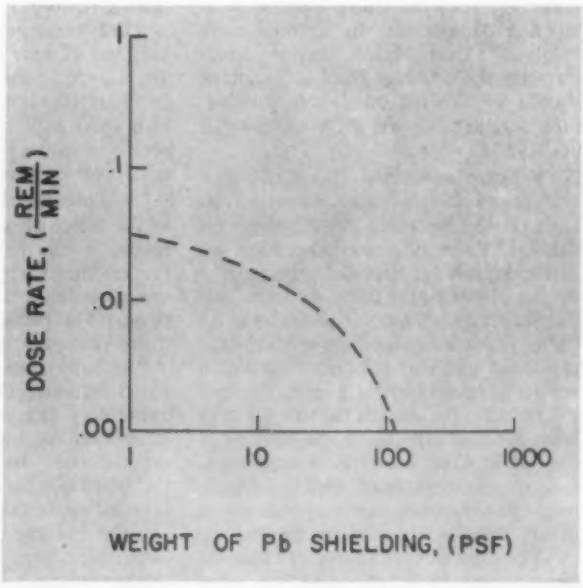
For man, the relatively small amount of high-atomic-number nuclei may be of extreme importance. No biological damage attributable to heavy cosmic-ray primaries has been found. The biological significance of the multi-pronged stars found in nuclear emulsions exposed at high altitudes is not known. But such stars resulting from the collision of very-high-energy particles with an atomic nucleus in living tissue must represent a very damaging microscopic explosion of energy.

• **Avoidance techniques**—The most thoroughly defined space radiation is the inner Van Allen belt, says Norris F. Dow, of General Electric's Space Science Laboratory.

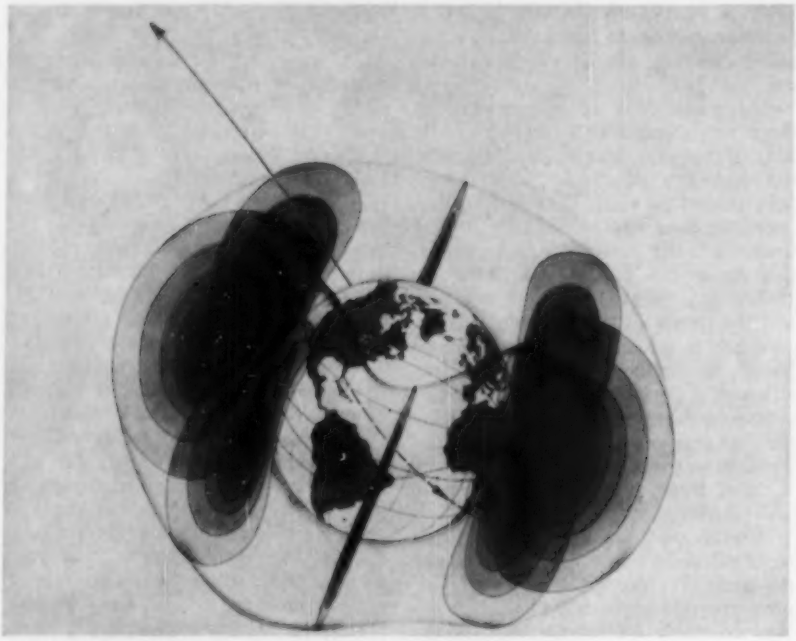
The inner zone appears to be stable, showing little variation with solar activity. It is also characterized by the presence of high-energy protons. The outer zone fluctuates in radiation intensity and spatial extent. The fluctuations have been induced by solar activity.

Only a general estimate is possible with regard to tissue ionization dosage and penetration. The general rule





LEFT: *Minimum weight of shielding required in inner Van Allen belt to give indicated whole-body dose rates.* **RIGHT:** *Estimate of requirements during solar burst. Dashed curve is for order-of-magnitude purposes, since solar data is inadequate.*



MARTIN CO. SKETCH of Van Allen belts shows a space vehicle trajectory plotted to avoid the greater portion of the belts by escaping along a polar region.

adopted for manned space flight is that the Van Allen belts can be ignored to a great extent. Some authorities have suggested that man be launched in trajectories through the polar regions in order to avoid the belts.

Others have pointed out that this may not be necessary if the transit time through the belts is of a short duration. This probably will be demonstrated in the *Apollo* program.

On the other hand, if shielding must be provided against the possibility of intense solar flares on long missions, the shielding for the lower-energy Van Allen radiation will be automatically resolved. Even brief transit times through the intense band of protons should be avoided on a long mission, however, because the crew exposure is additive.

• **Space sunburn**—The major barrier to meaningful man-in-space missions is the sporadic contributions of the sun. Years of observation have led to the knowledge that the gross energy output of the sun is fairly constant. But the relatively minor variations that do occur make interplanetary space in the region of earth and its sister bodies a very unpleasant environment for man.

Luckily, the sudden bursts of energy from the sun arriving in the vicinity of the earth have been fairly well catalogued in recent years and apparently relate to the development and decay of a very small active area on the sun.

The most intense source of radiation encountered in space originates from the solar flare—a sudden, short-lived brightening of the solar surface in the neighborhood of a sun-spot.

A. D. Goedeke of Douglas Aircraft Co. points out that these sporadic events are very common. During the International Geophysical Year (July, 1957-December, 1958) a total of 6762 flares were actually observed.

Only a handful of these were connected with the arrival of protons in the vicinity of the earth. But these energetic clouds have increased the free-space cosmic ray counting rate by a factor of 1000. It is generally believed that this proton flux is omnidirectional in the earth's vicinity.

The frequency of the events varies over the 11-year cycle of solar activity. The current period is one of low activity. Unfortunately, the next period of high solar activity begins in 1967—approximately the time of the first extended *Apollo* missions.

• **Conditional data** — With respect to the effect of all ionizing radiation in space, Norris believes there is reason for optimism regarding the successful use of common structural materials, and reason for pessimism about the adequate protection of man.

In both cases, current knowledge is based on extrapolations. No significant amount of data exists on the combined effects of radiation and hard vacuum on materials. It is possible, especially for plastics, that the combined effects may be worse than radiation alone.

The radiation effects on metals are negligible. Structural plastics are considered more vulnerable, and damage may be expected in typical reinforced plastics when they have received doses equivalent to about 30 million rad. The most sensitive plastics are damaged by approximately a tenth of this.

Norris says that compared to the intensities existing in space even at the highest levels in the lower Van Allen Belts, the damage threshold values are so high that, evidently, materials could exist for many years without deterioration. But the electrons in space, while less penetrating than protons, may appreciably reduce the lifetime of external surface materials from these values.

With man in the picture, the situation is reversed. Man's relationship to radiation involves a consideration of a number of relative terms. For years X-ray dosages have been expressed in roentgens—which is an exposure dose defined by the production of 1 statcoulomb per cubic centimeter of air at standard temperature and pressure. Rads seem to be the more correct terminology when referring to man; one is defined as a unit of absorbed radiation equal to 100 ergs of energy absorbed per gram.

The Atomic Energy Commission uses the term rem (roentgen equivalent man), but there seems to be little agreement as to its efficacy. It was introduced to reduce the expression of doses from different types of radiation to a common basis, in order to permit addition. It is defined as a radiation dose of any ionizing radiation estimated to produce a biological effect equivalent to that produced by 1 roentgen of X-rays.

The dose in rems is equal to the dose in rads, or roengtens, multiplied by the relative biological effectiveness (RBE) of the radiation involved for the situation in question.

RBE is the experts' favorite term for describing the hazards to man in space. Loosely defined, it is proportional to the amount of energy absorbed along the path of the ionized particle.

This linear energy transfer to the biological media is defined either in terms of specific ionization, the number of ions per unit of path length, or in terms of linear energy transfer, the loss of energy along the path of the ionizing particle.

• **Valid doubts**—A. M. Weinberg, Director, Oak Ridge National Laboratory, says the measurements of solar flare radiation, if not Van Allen Belt radiation, are uncertain by a factor of 10. He adds that the RBE of fast heavy particles used in all of the calculations on space shielding have been much lower than the RBE recommended in Handbook 69 and used in shielding estimates required for the manned nuclear aircraft.

Weinberg says the difference is usually justified by the difference in energy of the radiations in the two

(Continued on page 59)

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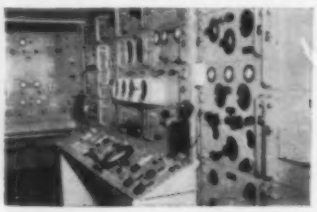

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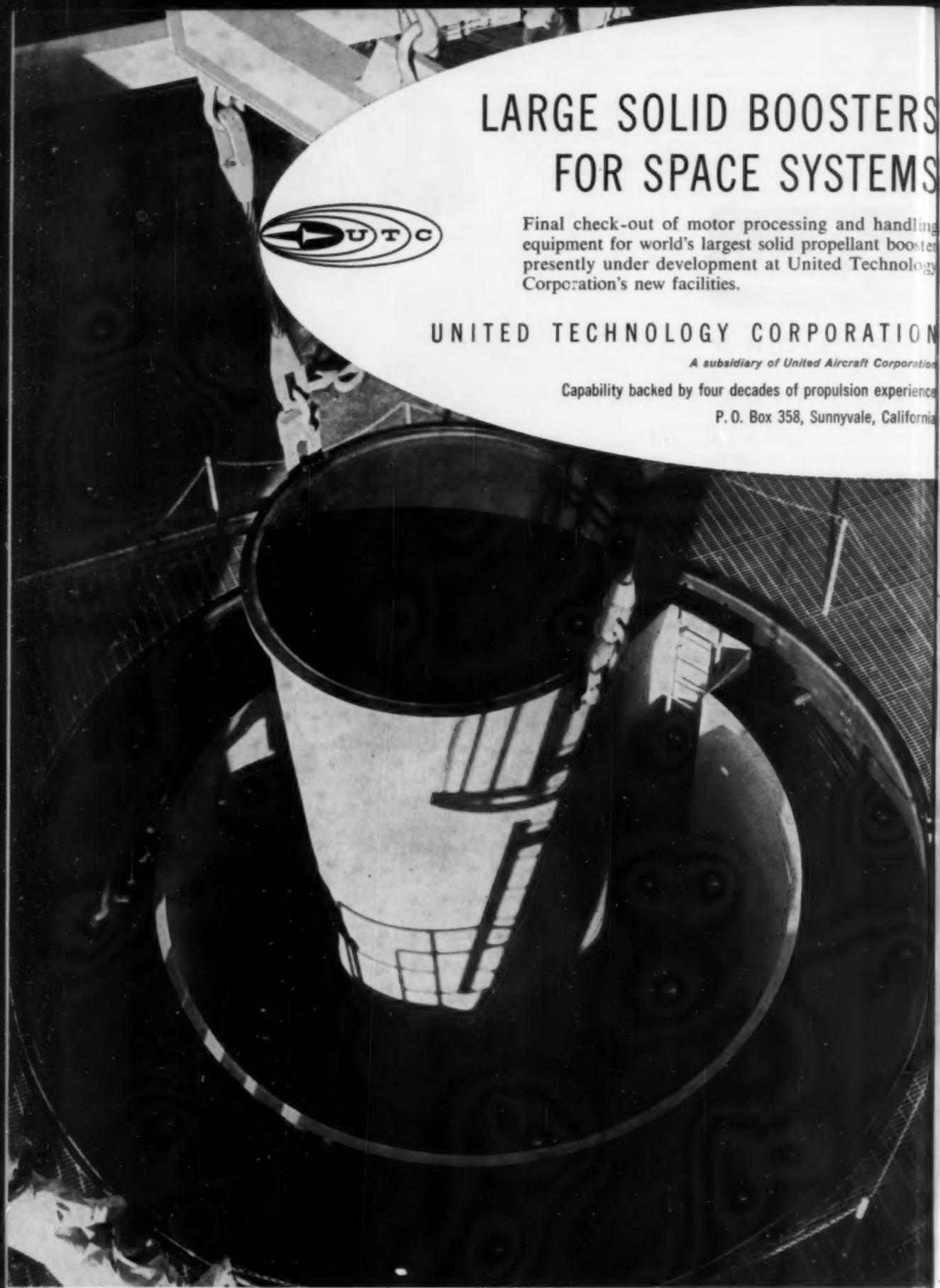

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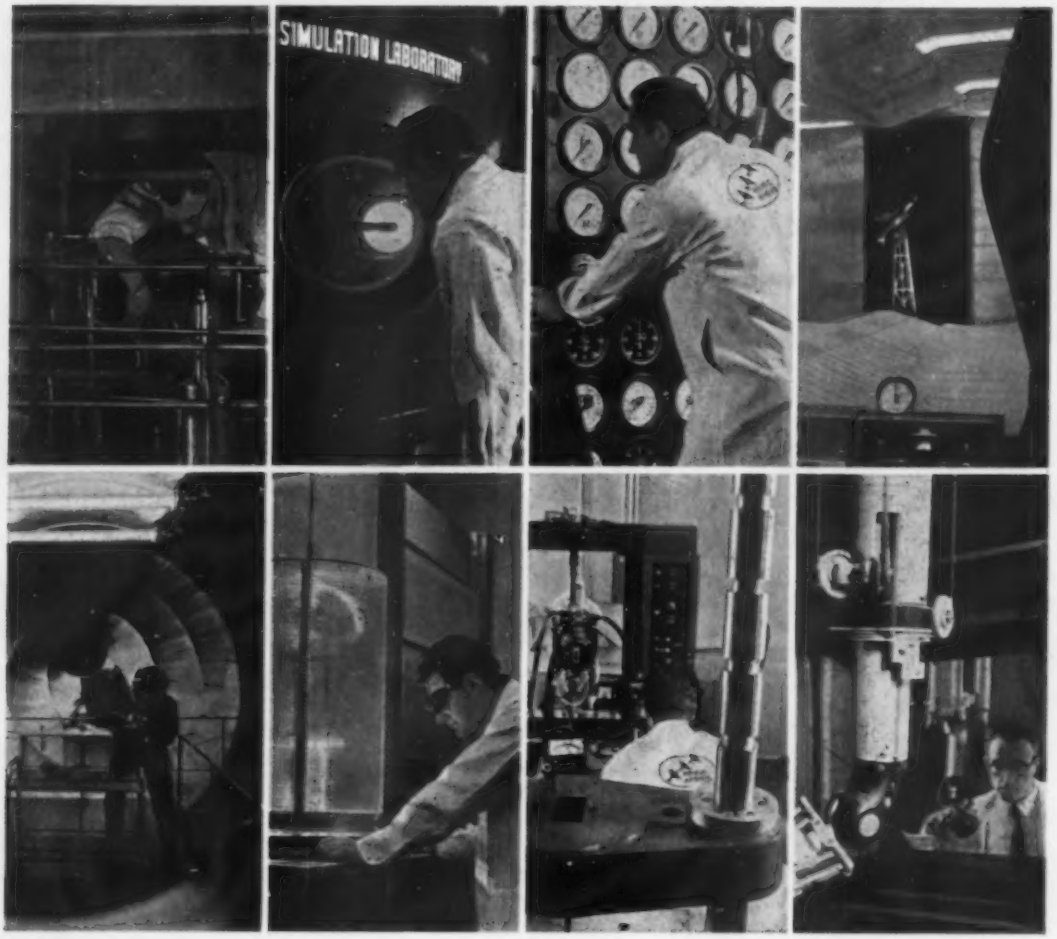

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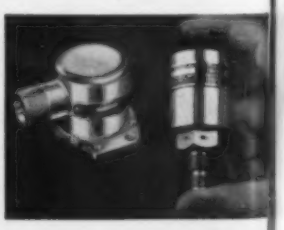

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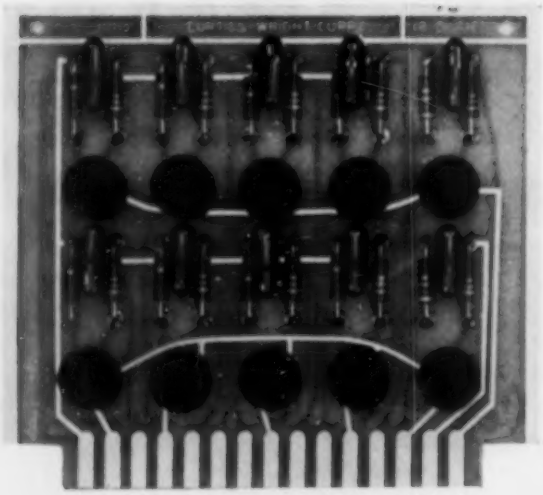

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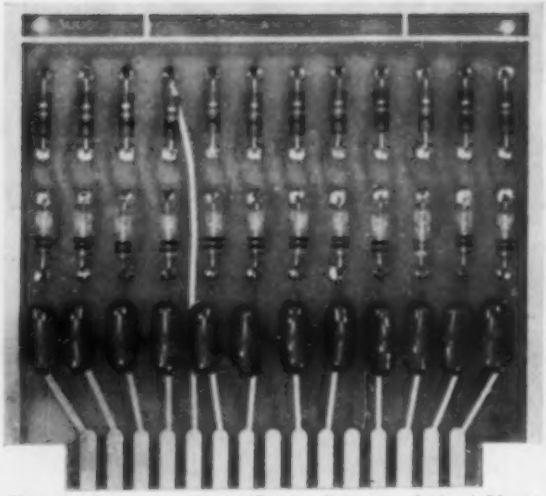

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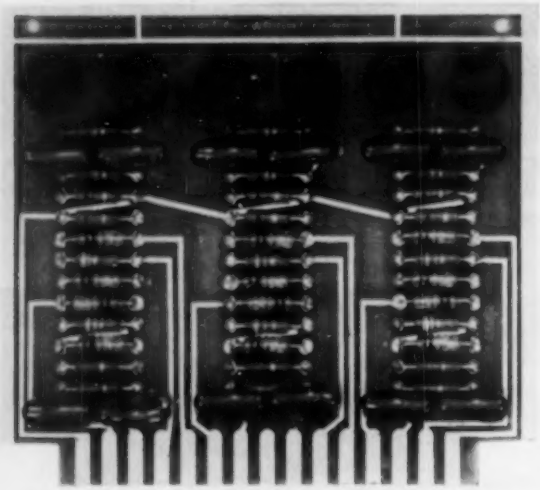
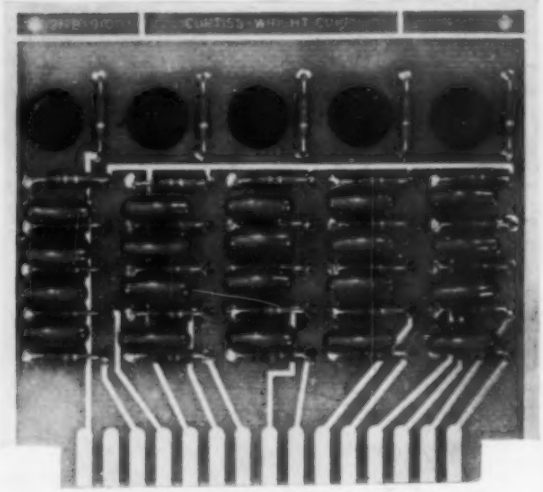


Three Binary Circuits with Set-Reset Gates (Actual Size)



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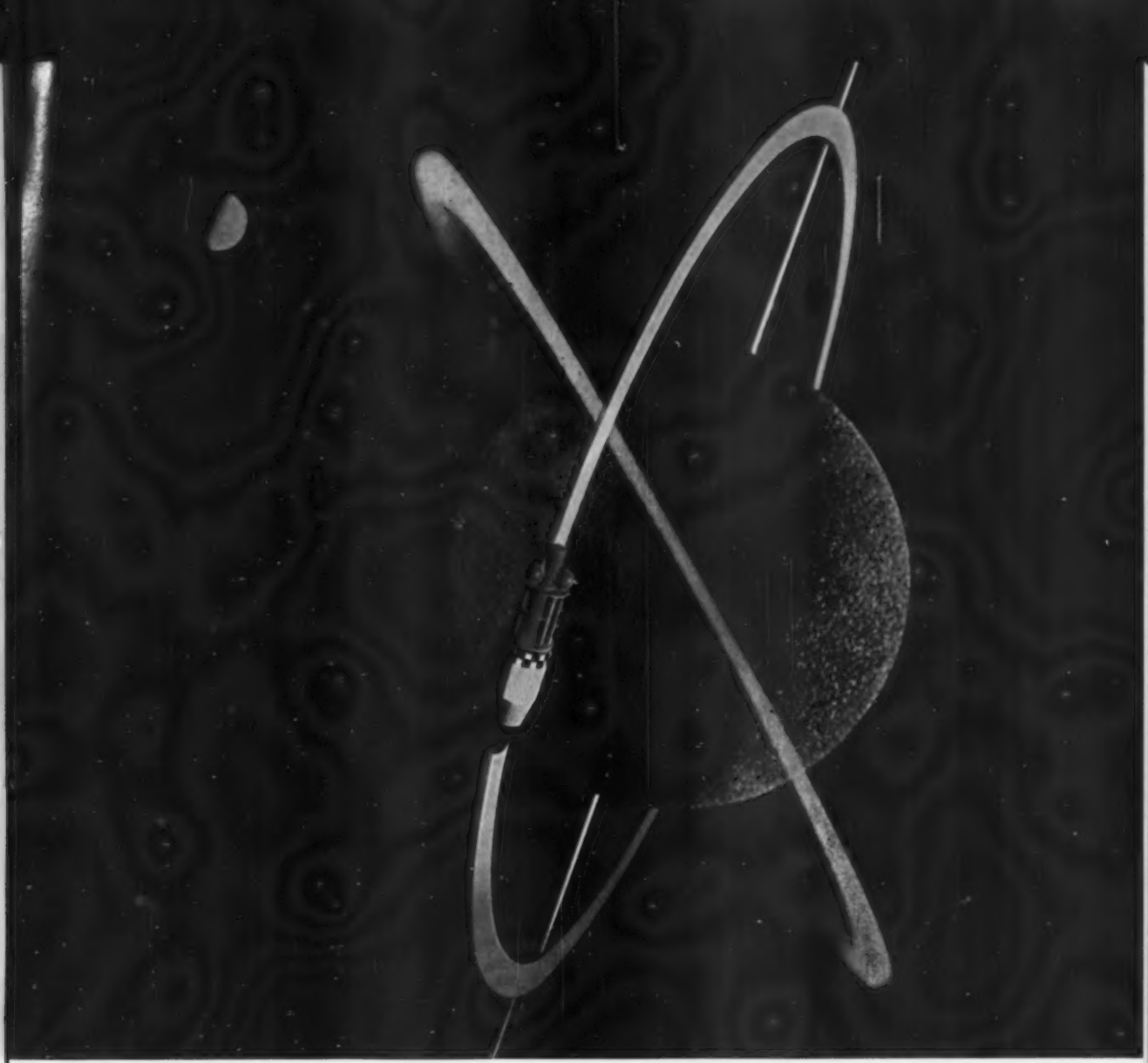

Bell-powered Agena satellites in orbit — symbolized.

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The Agena engine, designed with space in mind long before space became a household word, has fulfilled its every mission and has placed more tons of useful payload into orbit than any other power plant. Its operational reliability is backed by six years of development and 5,000 test firings.

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Agena's engine is typical of the exciting projects in Bell's rocket propulsion center. It is part of the dynamic new approach of a company that's forging ahead in rocketry, avionics and space techniques. These skills serve all government agencies. Engineers and scientists anxious for a new kind of personal challenge can find it at Bell.

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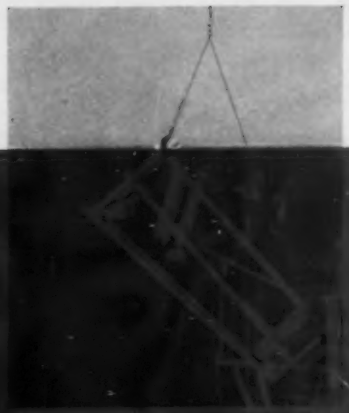
EXPLORING THE HIDDEN SURFACE OF THE WATER PLANET



EG&G Underwater Camera, Light and Sonar System

Fig. I

Fig. I. Ilia Galloway Diving Bell.

More than one hundred million square miles of Earth's surface are completely unknown to man. These are the super-continents that lie more than a thousand feet under the ocean, where sunlight has never penetrated.

A total of about one square mile of this unknown world has been photographed in various oceans by EG&G automatic underwater cameras. Positioned by EG&G sonar equipment and using EG&G flash equipment for illumination, these cameras have made excellent photographs at 27,500 feet below sea level where the pressure is more than seven tons per square inch.

EG&G is also deeply involved in control instrumentation for the first nuclear rocket engines (Project Rover), the international program for detection of nuclear explosions (Project Vela) and instrumentation systems for non-military applications of nuclear explosions (Project Plowshare).

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(Continued from page 50)

cases—space radiation, being harder, has a low linear energy transfer and therefore should have a low RBE.

But the total experimental evidence on the relative RBE of very fast particles is not very large and, in any event, the secondary particles produced in spallation processes, such as occur with energetic primaries, are in the binding energy region, not the 100 Mev area.

The Air Force report notes that the effects on living systems of all ionizing radiation begin on a biochemical and biophysical level and, depending on the magnitude of the dose, may be immediate or delayed. But there are many physiological factors which determine the effect of total body radiation—that radiation most likely to occur in space. There is little doubt that among men there is a considerable variation of sensitivity. The fact that 300 rem will be lethal to one man and 1000 to another, while both are apparently in equally good health, remains a mystery.

• **Leading from ignorance**—The lack of data forces the designers of spacecraft to assume the worst and prepare for it. Dose levels widely used today are drawn from and intended for those who work with radioactive substances. Breaking down these values with respect to space radiation effects on an astronaut leads to a great level of disagreement among the experts. There is also a recovery factor, which offers possibilities for more flexible definitions of dose permissible for man in space.

The shielding question is usually treated in terms of active and passive methods. The overall problem, stated in terms of lead shielding by Norris, illustrates the magnitude of the situation.

Weights of lead shielding less than some 10 to 20 lbs./ft.^{2} are essentially as useless for stopping inner Van Allen radiation as they are for cosmic rays. Extremely heavy weights of lead are required to reduce dose rate appreciably.

Passive shielding simply means the use of inert materials to absorb or deflect the incident radiation. S. F. Singer has concluded that a composite shield is needed to combine the proton-stopping power of low-atomic-number elements with the generally desirable characteristics of the high atomic number of lead. But Norris points out that unless the exact spectrum of energetic particles to be shielded is known, the design of a composite shield more effective than lead appears hardly feasible.

Norris suggests that it might be fruitful to take advantage of the generally oriented nature of space radiation, and the fact that protons are decelerated in a material in essentially straight lines. On this basis, if the shield is oriented askew relative to the path of the incident particles the protons will travel in part along the shield instead of directly through.

Thus a thin, saucer-shaped vehicle oriented edgewise to the radiation should be more effective than a sphere.

Active shielding involves the use of electrostatic or electromagnetic fields to deflect the incoming protons. Norris says that the assumption must be made that protons are the particles to be shielded; if energetic electrons are encountered in significant quantities, they are prevented from penetrating by some additional type of shielding.

In electrostatic shielding, the rejection potential in volts must be numerically equal to the kinetic energy of the incoming proton in electron volts. Then, in order to protect a sphere of any radius against protons in the 200 Mev range, it must be given a positive charge equivalent to 200,000,000 volts.

The concept does not appear encouraging, inasmuch as ground-based electrostatic accelerators using heavy equipment achieve only some 10 million-volt potentials. But the vacuum in space should permit the build-up of much higher charges than are possible in the atmosphere.

Electromagnetic shielding suffers a weight penalty in the needed equipment, and the vehicle has to be properly oriented to give equatorial incidence to the incoming radiation. There are also complications in the operation of a vehicle within an intense magnetic field.

• **The great compromise**—The task of shielding man for extended durations in long space missions is quite formidable. The short-flight approach involves certain avoidance techniques—such as that envisioned by the Martin *Apollo* studies. There is also the possibility of including a "storm cellar" in a craft for use during high radiation flux.

The storm cellar could be combined with avoidance techniques for a larger margin of safety. A. D. Goedeke says that it may be possible to avoid major solar activity during the 11-year cycle. (M/R, April 17, 1961, p. 31.)

One other method involves designing the spacecraft in such a manner as to put all equipment between the man, or men, and the environment. This seems to be the procedure followed in the Martin studies. There the capsule surface was divided into 500 separate segments. Positioning equipment left only a dozen or so to be shielded.

The great lack of reliable information is constantly cited as the major immediate problem.

It is generally agreed that exposures close to the level of acute injury must be accepted as inevitable in space flight. Many experts feel that space flight radiation studies in a biochemical and biophysical sense have been neglected.

On May 4, 1961, a special subcommittee of the House Committee on Science and Astronautics heard this from Col. Charles H. Roadman, NASA Director of Life Sciences Programs:

". . . I think it is evident in their (Russia's) program that they have had . . . an extensive biological in-flight effort. They have had some six flights with a considerable number of biological specimens being on board.

"As it relates to our program, we are really behind, if you want to put in this comparison, in our ability to put biophysical level and, depending on the

It seems that the U.S. is once again long on theory but short on results—where they count. ■

MONTH	IMPORTANCE (1−)	1	2	3 AND 3+	TOTAL
1957 JULY	28	334	39	5	406
AUG	36	320	25	2	383
SEPT	50	368	53	10	481
OCT	71	436	21	2	530
NOV	35	275	18	2	330
DEC	37	298	27	0	362
1958 JAN	13	196	23	1	233
FEB	9	215	24	0	248
MAR	38	352	54	4	448
APR	35	295	14	1	345
MAY	53	313	18	2	386
JUNE	91	254	32	1	378
JULY	90	340	31	3	464
AUG	86	335	33	4	458
SEPT	71	305	28	1	405
OCT	27	279	23	0	329
NOV	29	189	14	2	234
DEC	36	285	20	1	342
TOTAL	835	5389	497	41	6762

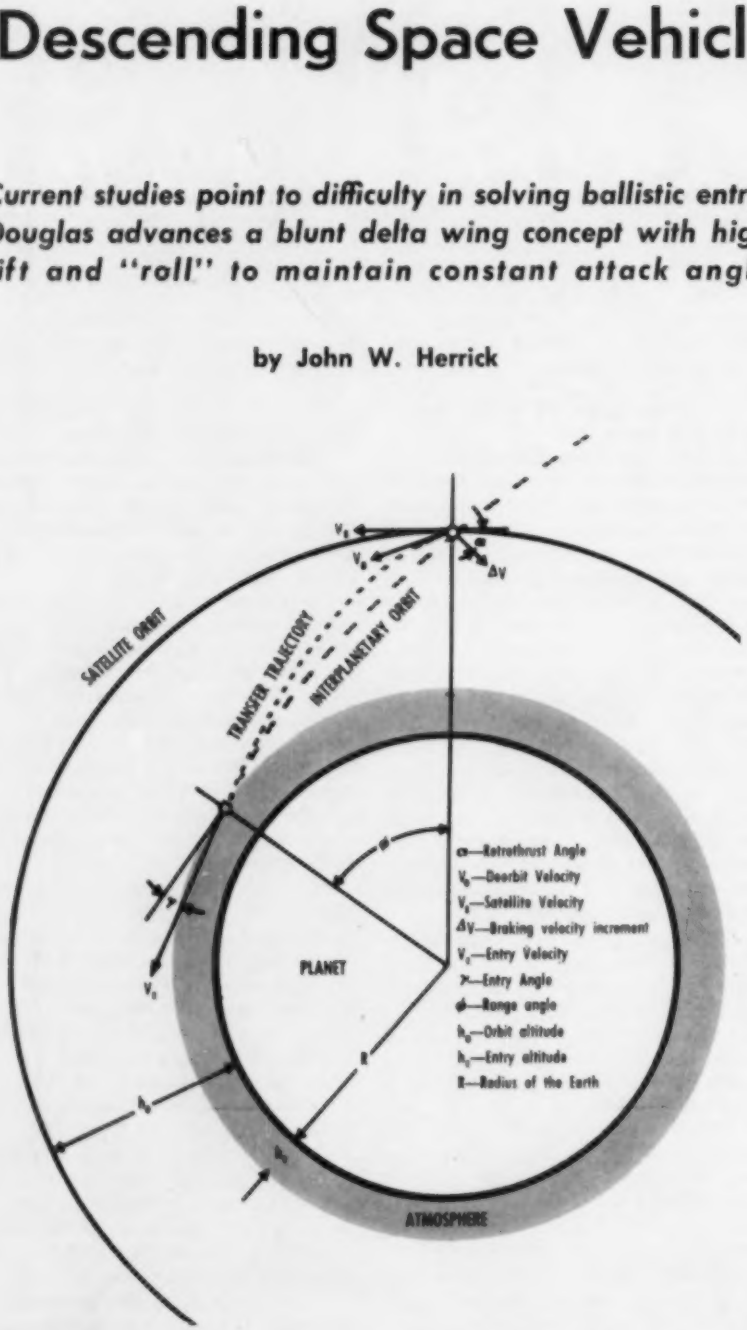
CATALOGUE OF SOLAR RADIATION EVENTS detected during the IGY. Importance figures denote the area of disk on the sun at maximum brightness.

To hit entry corridor . . .

Descending Space Vehicles Should Have a

Current studies point to difficulty in solving ballistic entry; Douglas advances a blunt delta wing concept with high lift and "roll" to maintain constant attack angle

by John W. Herrick



ENTRY ANGLE as shown in graph will be critical—particularly for craft returning from interplanetary orbit. High g will result at 6° or more.

A MANNED spacecraft correctly designed for entering an atmosphere—whether earth's, Mars', or some other planet's—must satisfy three major requirements.

It must have a heat shield, insulation, and other equipments that will prevent overheating of the load-carrying structure and the internal contents—including frail humans—during entry from space as the vehicle dissipates its kinetic energy.

The spacecraft must be operated and controlled in a manner that prevents overstressing the human passengers and the structure during deceleration by the atmosphere or application of reverse thrust (retrothrust). In short, keep the g-load within tolerable limits.

Lastly, the landing craft must have maneuverability and controlability that will make it possible to land at a desired location, preferably a ready airfield. This is the aspect of manned space travel that will next receive large-scale attention now that the *Mercury* program, the Gagarin flight, and the *Discoverer* recoveries have demonstrated the feasibility of re-entry in the manner of ballistic nose cones.

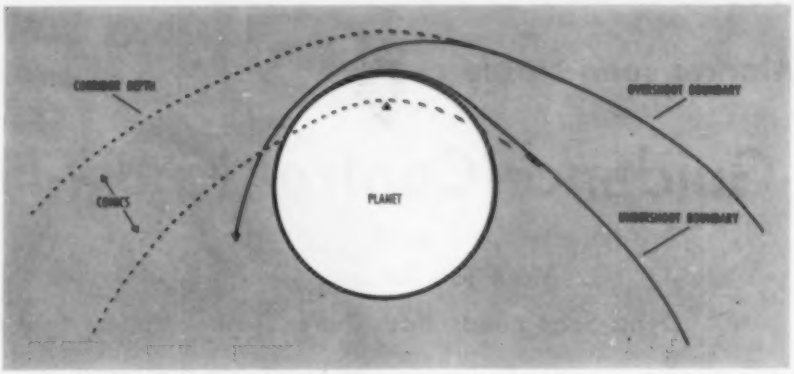
Suborbital flights of the *Mercury Redstone* capsule down the Atlantic Missile Range resemble ballistic trajectories except for the deployment of a parachute to obtain final deceleration before dropping into the water. Some authorities question the value of these flights because the capsule does not adequately simulate true orbital re-entry.

There are other requirements, believed to be minor compared to those noted above but important nevertheless, that should be considered in a thorough study of return, re-entry and recovery.

1. The manned vehicle should be reusable. (This is in line with current plans to recover the large and expensive rocket boosters.)

2. The system should be capable of acceptable entry from the moon or the planets as well as from an earth orbit. Simply stated, the system would work at 35,000 ft./sec. (near escape velocity)

ave Variable Drag



NARROW CORRIDOR emphasizes danger of undershooting or overshooting earth. Returning astronauts could miss proper angle and whiz into space again.

as well as at the velocity for a low-altitude satellite; for example, 24,000 ft./sec.

3. The system should be usable for an emergency recovery at any time during ascent from the launch pad.

4. The pilot should be a functioning part of the control loop during descent and should have adequate communication through the plasma sheath that builds up in front of an entering object.

5. Materials used in the spacecraft structure should be compatible with space as well as earth environments.

• **Variable drag must**—Conclusions reported by the experts at the Lifting Re-entry Vehicles Conference managed by the American Rocket Society at Palm Springs were generally in agreement with authorities subsequently consulted at Douglas Aircraft Co., Space Technology Laboratories, Radioplane Division of Northrop Corp., and North American Aviation.

The manned re-entry vehicle must have some capability for varying its drag during descent from orbit.

If this drag modulation is accomplished by using a lifting-type vehicle, the maneuverability and controlled landing problems are greatly lessened.

Uncontrolled landing anywhere in the predicted 50-by-300-mile ocean area for the *Mercury* astronaut is hardly conducive to establishment of acceptable space transportation. Studies of the combined effects of errors in retrothrust angle, variation in total retrorocket impulse (output), and expected tracking accuracy with the *Mercury* network at the time of retrorocket-firing lead to one big question—how far from the center of the desired landing area will the *Mercury* astronaut actually touch down?

The original planning of the *Mercury* program, however, was logical on the basis of the then-current state of the art, the limitations in financial and political support, and the natural desire to orbit an American as soon as it could be done with minimum risk.

It becomes obvious to those who seriously study entry and recovery technology that the returning vehicle should have some of the design features of a supersonic airplane. Ballistic-type nose cones that decelerate by compressing the atmosphere they are ramming through are acceptable only for the initial tests and investigations.

• **One solution**—The Douglas thick-wing planetary vehicle, proposed by Gervais, duPont, and Lowe, attracted considerable interest at the Palm Springs meeting. This concept provides a means of reducing both maximum heating rate and total heating by entering the atmosphere with the winged vehicle placed at a high total angle of attack.

Total heating encountered and maximum deceleration loading are significantly reduced by a controlled angle of attack. Because this concept is typical of other lifting-type entry vehicles, the major design features will be reviewed.

An exhaustive review would include features and discussion on *Dyna-Soar*, advanced *X-15*, asymmetric lifting bodies, and the folded-wing configuration proposed by Eggers of NASA.

• **Re-entry fundamentals**—Most investigators examine the entry problem from the point of view of the entry velocity of the vehicle. The two broad classes are: The velocities appropriate to low-altitude earth satellites, about 26,000 ft./sec, and those appropriate to return from space (for example, our moon), about 35,000 ft./sec.

Dr. John Sellers of Space Technology Laboratories divides the entry portion of the return trajectory into three regions.

The first region is that of the extremely high altitude where the returning spacecraft is first affected by the atmosphere. The second region is where extremely high heating and deceleration are experienced. The third is the terminal region where the aerodynamic forces acting on the vehicle are comparable to the force of gravity (the region of "slow fall") and the re-entry body actually begins to cool.

It is instructive to consider this general entry trajectory in more detail. For simplification a zero-lift body is used as an example.

A nose cone will start to oscillate very slowly in the first region. If it is a statically stable nose cone, the angle of attack will thereby be greatly reduced. The forces causing this, however, do not reduce the velocity. In fact, the vehicle may even accelerate slightly because of gravitational attraction. It is during this regime that an attitude-control system should damp out the oscillatory motion.

At an altitude of approximately 200,000 ft., depending somewhat on the design, the nose cone enters the second region. The body drag will just equal the acceleration due to gravity, and the nose cone will reach maximum speed. From this point on, the drag builds up so rapidly that the gravity term in the analyses can be completely neglected.

It is during this region that the extreme deceleration loads and heating rates commonly associated with re-entry are experienced. It is here that the kinetic energy (a heavy mass of several thousand pounds at velocities above five miles per sec.) is used up by producing thermal energy in the surrounding atmosphere.

• **Balloons & Gliders**—During the terminal region, the "slow fall," the major problem is aerodynamic stability, and gravity has to be considered. It is in this region that various drag or deceleration devices would be useful. The major aerodynamic decelerators that are being studied include attached types and trailing types, categorized by the manner that they are connected to the landing vehicle.

A list of the attached types would include: Autorotors, semirigid flaps and spoilers, rigid flaps and spoilers of which extensible flares is one popular design, and the Rogallo paraglider (see M/R, May 15, p. 40). Parachutes of all shapes and arrangements lead the list of trailing decelerators. Others are balloons, cascades (a strung-out series of plates, cones, etc.) and towed afterbodies.

Although the entry velocity of a body is an important factor to be con-

(Continued on page 94)

Market seen stable . . .

Guidance/Control Know-How Is Ample

Main job for manufacturers is systems integration—
Dyna-Soar needs have taken shape but debate over Apollo continues

by Charles D. LaFond

EXISTING guidance and control hardware types and techniques are expected to be used in the new space vehicles *Dyna-Soar I* and *II* and *Apollo*.

Hence these G&C systems will not be delayed by any lack of technological know-how, and the principal task facing manufacturers appears to be systems integration.

The total guidance and control market for manned space vehicles, in fact, will not exceed $115 million over the next five years. Industry observers say that because of the very small number of existing programs and their inherent low production potential, the market will be stable for the next five years—and possibly throughout the next decade.

Dyna-Soar G&C requirements are now fairly well set, but among the prime-contract contenders there are conflicting views as to what approach would be best for *Apollo* guidance. Some would prefer to rely heavily on radio command; others believe all-inertial is sufficient as the primary subsystem. All expect that some form of celestial navigation backup and mid-course guidance will be employed.

There is unanimous agreement that man will greatly complement and possibly even simplify guidance and control systems for relatively long-distance flight vehicles.

• **Market low, steady**—About 20 percent of the 1961 $90-100 million space G&C total will be directed toward systems for manned space vehicles. This figure includes R&D. Further, it is not expected to vary a great deal over the next 5-6 years.

The market in calendar year 1961 is expected to reach about $22 million.

There are four current or projected programs: *X-15*, *Mercury*, *Dyna-Soar I*, and *Apollo*. Only the latter two will continue to require any sizable expenditures. *X-15* and *Mercury* have reached the point where hardware and product improvement account for almost all funding and these are diminishing markets.

Dyna-Soar I probably will phase out in 1964-65 as *Dyna-Soar II* comes into development. Cost of the whole *Dyna-Soar I* G&C system is expected to run from $45 to $50 million. Nearly $5 million has been allocated so far by Air Force and Boeing to Minneapolis-Honeywell, developer of both systems. This should reach $6 million by the end of this year, then steadily increase.

By the end of this year or early 1962, the first *Apollo* contract—probably preliminary design—should be awarded. Total G&C development cost up to and including the circumlunar vehicle is estimated to be anywhere from $20 to $30 million. Over what time period this will be spent is not now known.

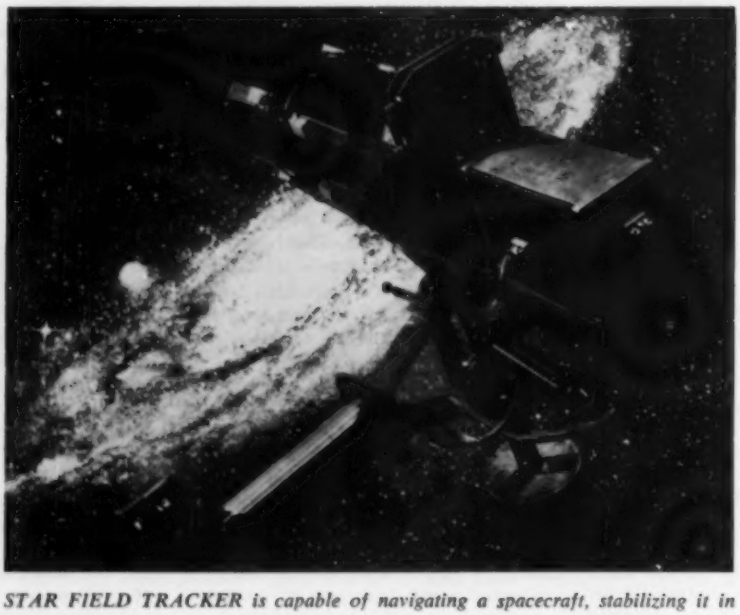
Only a relatively small amount of government funding has supported the just-completed *Apollo* feasibility studies. Martin, General Electric, and Convair each received $250,000. The unknown quantity here is how much each invested of this amount plus company funds for the G&C studies performed by Arma and Autonetics (for Martin), Nortronics (for Convair and by GE itself. Added to these totals would be expenditures by companies like Boeing and McDonnell who performed the entire study solely on company funds.

Around 1964, *Dyna-Soar II* will be phased in. Also, it is very possible that the often-mentioned Aerospace Plane may come into being in 1963 or 1964. Both will add more money to the pot.

With all these imponderables in in mind, the best (conservative) projected estimates for the manned-vehicle G&C market look like this:

1961—$22 million
1962— 28.5 million
1963— 22 million

(Continued on page 65)



STAR FIELD TRACKER is capable of navigating a spacecraft, stabilizing it in flight, and guiding it to landing on moon's surface. Tracker, developed by Martin Co., simplifies space-navigation problem by map-matching against selected constellation of group of stars as reference point to determine spacecraft's orientation and produce necessary signals to guide it on its path. With same techniques, device can follow approaching lunar contours to guide vehicle to preselected landing point on the moon. System can be used as backup for Apollo inertial guidance system.

Said Hans Oersted: *"When a conductor carries current through a magnetic field at right angles to it, the resultant reaction thrusts the conductor in a direction perpendicular to both the current and the magnetic field."*

A light-weight, low fuel-consuming propulsion system is a primary requirement for interplanetary space vehicle travel. One such system now being carefully studied utilizes plasma propulsion.

This concept employs an electrical field to produce a plasma and to energize it. A magnetic field then ejects the plasma, thereby providing a reactive thrust to the vehicle.

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(Continued from page 62)

1964— 16.5 -18.5 million
1965— 15-22 million
Total: $104-113 million

• **Dyna-Soar G&C**—Requirements for the Air Force's experimental boost glider, *Dyna-Soar*, will be rigid. The manned delta-winged hypersonic vehicle must permit complete control by its pilot from launch into orbit, during orbital coast, and throughout its gliding re-entry and subsequent landing. All this will be accomplished within a circle of maneuverability of several thousand miles diameter.

Velocities will range from nearly 18,000 miles/hour (orbital speed) down to conventional military jet-aircraft landing speed.

Primary guidance and the adaptive flight control system for the craft will be developed by Minneapolis-Honeywell Regulator Co.

The guidance subsystem will include a four-gimbal inertial platform, platform electronics, digital coupler and power supply, malfunction detector, and digital computer. Most of the inertial system is identical to that supplied by M-H for the *Centaur* program. Also, it is believed the *Dyna-Soar* guidance system will have a somewhat less sophisticated backup inertial platform.

Seven years in development, the prototype of the automatic electronic flight control system is scheduled for testing this September in NASA's *X-15*. Because of the similarity of operation, design problems, too, are similar for the two vehicles. The *X-15* should produce meaningful data leading to final development of a reliable, high-performance system for *Dyna-Soar*.

The reason for the complexity of such a system is the difficulty in merging technologies of aerodynamic and reaction controls. Switchover from one technique to the other must be performed smoothly, and at the opportune time, to achieve optimum performance and fuel efficiency.

Dyna-Soar I will not be orbital. First tests will involve airdrop and ballistic unmanned flights. (For more details of *Dyna-Soar* G&C, refer to M/R, Feb. 27, 1961, p. 45.)

• **MAN control?**—Reportedly, Boeing Co., prime contractor for the vehicle program, is considering the use of a microwave guidance subsystem for recovery, at least during early phases of the test program.

Developed by Sperry Gyroscope Co., a Division of Sperry Rand Corp., the Microwave Aerospace Navigation System (dubbed MAN) will remotely control descent and landing of the spacecraft with great accuracy.

Employing long-range radar, MAN

(Continued on page 70)

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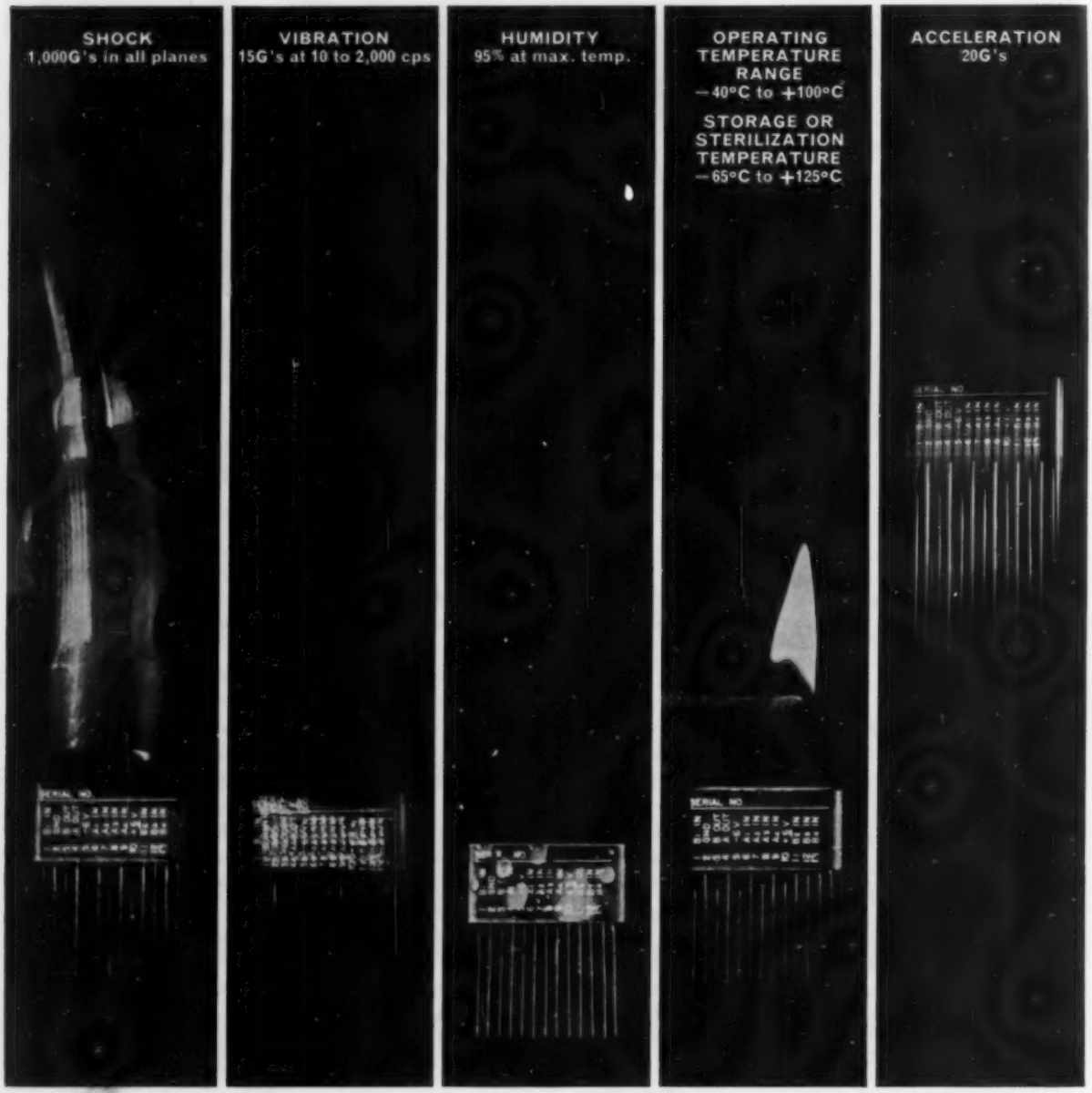

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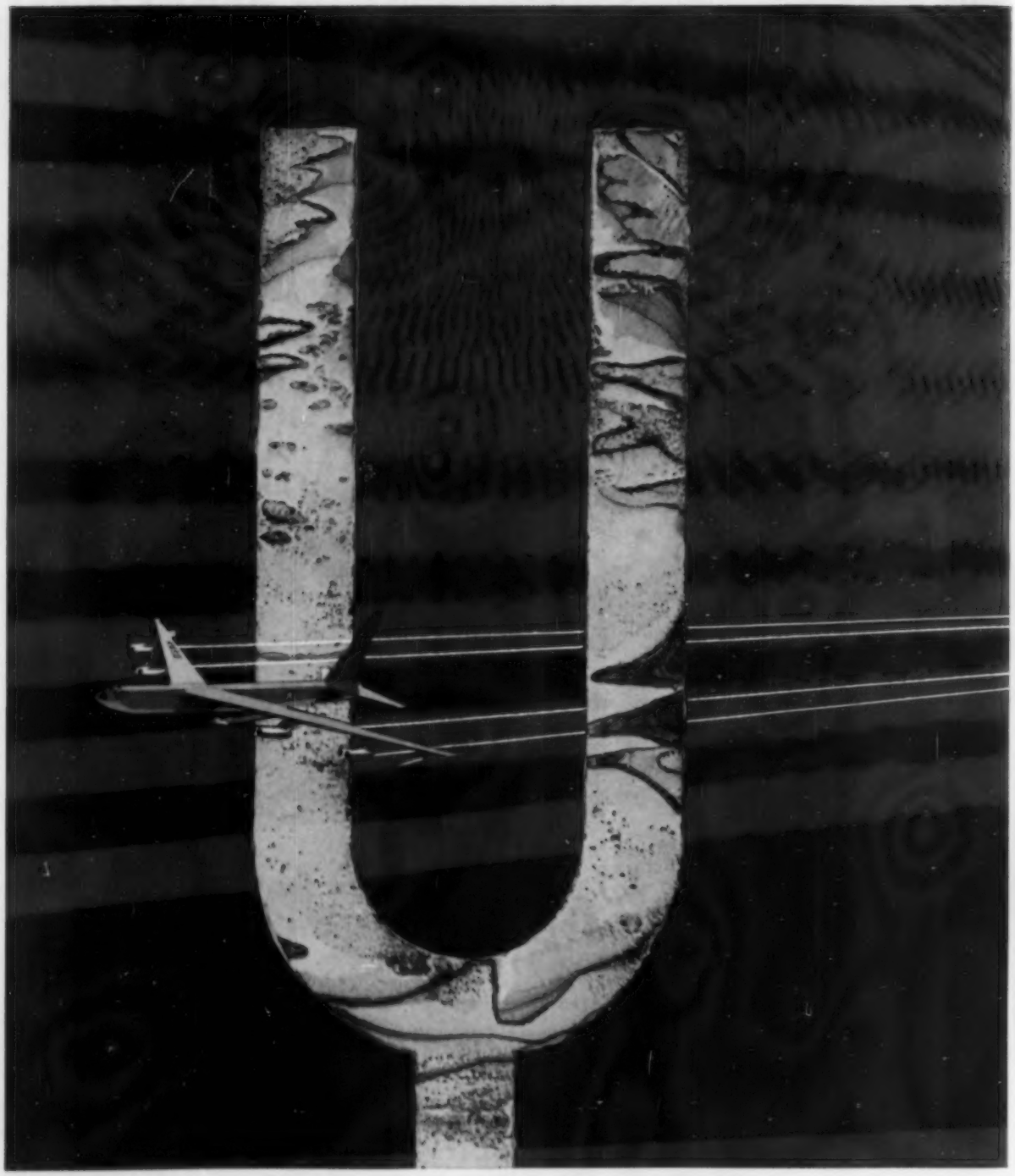

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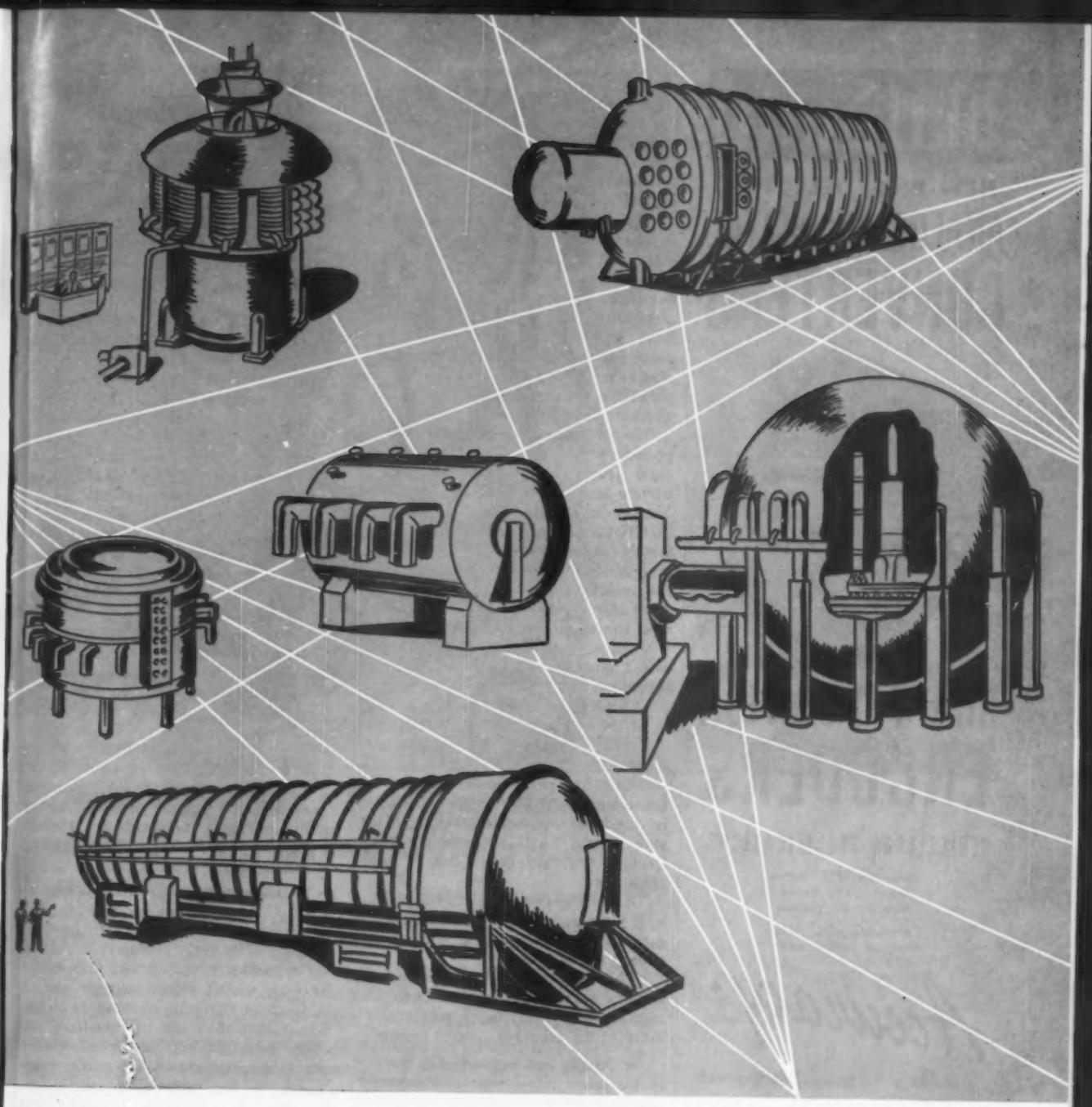

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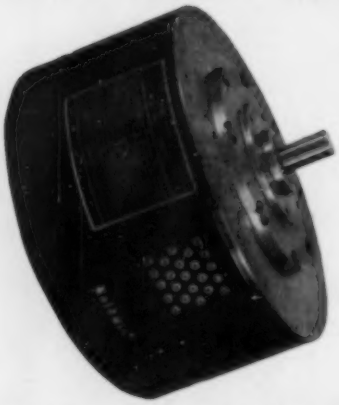

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(Continued from page 65)

takes over the navigation functions of the craft's own inertial guidance system. The system calculates and maneuvers a smooth approach, dissipates excess airspeed, and safely lands the vehicle at a prescribed point.

Any system of this type will have to acquire the vehicle just before reentry, follow it through, and at the same time calculate the re-entry corridor based on the point of initial injection. Obviously, a severe communications problem will exist during this phase because of the ion plasma sheath about the vehicle. This envelope attenuates radio energy over a range of frequencies from 100 mc to 10 kmc.

To overcome this problem and to provide accurate position and velocity data, Sperry has suggested use of a narrow-beam radar, extended by a beacon for longer range and employing a high X-band frequency. Command data will be provided by PCM (pulse code modulation) telemetering to and from the vehicle.

Radar, command link, and telemetry link functions can be integrated into a single system, Sperry says, to minimize hardware and greatly increase reliability.

The X-band radar interrogator used in MAN employs a PCM 5-kw magnetron transmitter with a very-low-noise receiver.

An 8-foot paraboloidal reflector antenna with a 0.9-degree beamwidth will be used for automatic tracking. This, says Sperry, will provide an angle tracking accuracy better than 1 milliradian rms.

A flight path computer will provide x, y plots and altitude. A miniaturized data transponder would be carried aboard the vehicle.

The addition of multiple ground stations and/or air relay stations tied together would add much greater flexibility to the recovery control system.

• **Apollo and beyond**—On the first major space trip—lunar circumnavigation and return—guidance will be one of the critical technical areas (others include thermal, meteroid impact, radiation protection). There are conflicting ideas as to just how tough the problem really is.

Dr. Albert C. Hall, Martin v-p/engineering, has described requirements for such an *Apollo* mission as follows:

Perfect coasting or "free fall" lunar flight requires an initial velocity of about 24,500 mph, or 36,000 ft./sec. Just to hit the moon, the guidance must guarantee an accuracy of within 75 ft./sec. and 0.5 degree of the planned flight path.

To circle the moon and return safely, the overall tolerances are considerably more severe: within 1 ft./sec. and 0.001 degree. This accuracy is roughly 20 times better than that required for an effective ICBM, Hall said.

Midcourse guidance and, of course, propulsion must be employed to achieve these accuracies.

NASA's Chief of Manned Space Flight, George M. Low, in his report "Manned Space Flight" said that trajectory control will impose very severe requirements on the navigation and control systems.

With a midcourse guidance correction capability, others feel, the problem is not so difficult. They believe there is a general misconception with regard to the long-distance guidance task.

Last fall, three Jet Propulsion Laboratory experts—C. R. Gates, A. M. Noton, and E. Rechtin—presented a paper before the Fifth Space Electronics and Telemetry Symposium in Washington which stressed that injection accuracy comparable to that of an IRBM would be more than adequate.

Their hypothesis is based on the employment of a "fuel-cheap midcourse maneuver" derived from inputs from moderately accurate radio tracking during the first several days of flight. Tracking errors, they said, need not be small, but they must be stable for compensation in the orbit computer programing.

With present application technology, G&C components have expected life of several hours maximum; for space use there must be several thousand hours minimum, says Gerhard B. Heller, deputy director, Research Projects Div., Marshall Space Flight Center.

• **Human control?**—In a comparison of man versus machine in the functional role of spacecraft control, man shows up very favorably. The original argument as to whether man could be truly useful seems strongly settled in favor of the man-machine combination, rather than just the machine, for every scientific role in space except near-space exploration and pure experimentation. For exploration, fabrication, maintenance, inspection, surveying, and piloting (particularly docking and landing), man obviously has attributes which either complement or greatly exceed the machine.

It is significant that the strongest technological barrier today to manned space flight is not an electronic or electromechanical equipment deficiency but the booster state of the art.

As for man himself in the control function, apparently most studies to date state that: (1) man can survive and perform as required, and (2) no limitations have been observed yet which will limit seriously man's normal

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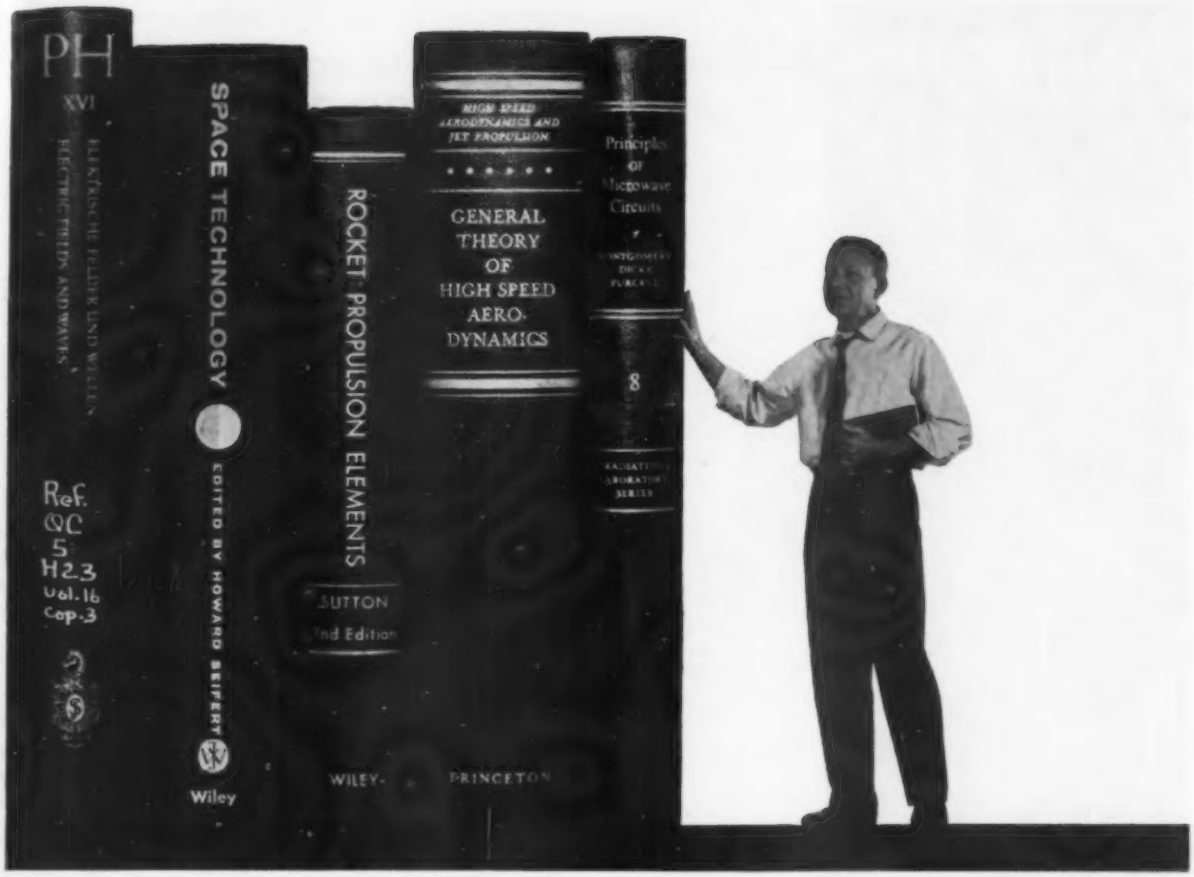

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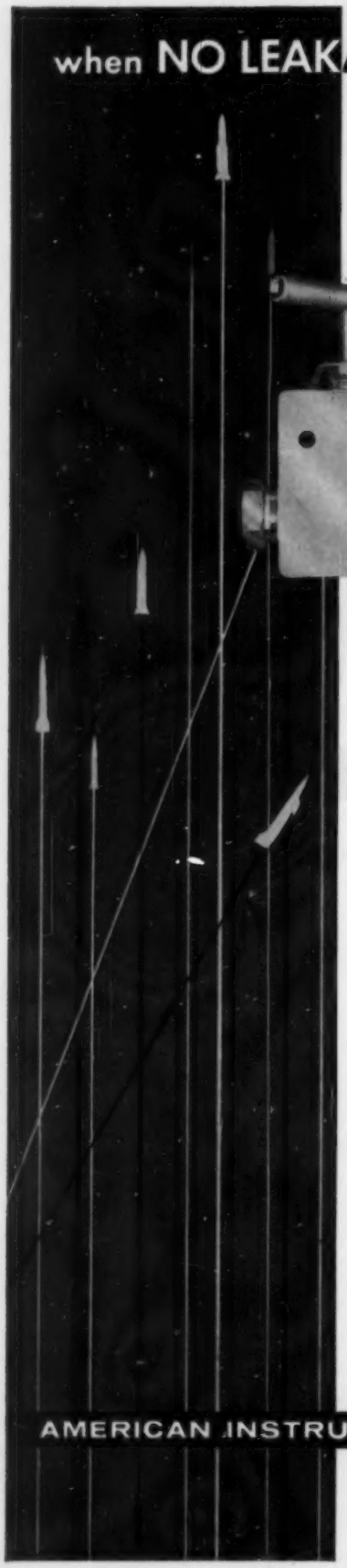

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(Continued from page 70)

operating capability.

The biggest unanswered question remains, however: How long can man perform in conditions of high radiation, weightlessness, isolation, etc.?

In his control function, man offers many characteristics vastly superior to the machine. He is self-programing, very flexible and adaptable. He employs a learning system, reasons inductively, and has an urgent interest in survival. As for reliability, man is not subject to catastrophic failure if before flight he is capable of passing exacting inspection.

Finally, man's weaknesses can be guarded, corrected, supplemented or completely bypassed by the machine.

One large question—how to assign decision-making—remains to be resolved. But this probably will have to be accomplished through experience. The question lies with degree or division of responsibility.

• **Reliability improved**—On any extended space flight, G&C will be one of the major systems requiring adjustment or repair. Here man's maintenance value could be highly rewarding.

According to Donald E. Burris, of General Electric's Missile & Space Vehicle Department, studies have shown that reliability of an unattended space system varies from 0.97 at the end of 1 hour to 0.20 after 12 days in flight.

However, by adding man for making adjustments, reliability after 12 days is held to 0.70. If repairs also can be made, reliability decreases only to 0.94.

It is true, he said, that longer unmanned flight periods are possible—but at the penalty of greatly reduced effectiveness.

• **Two G&C approaches**—Since NASA is contemplating the use of modular spacecraft design for *Apollo*, the command center module probably will be the same for earth-orbital missions and for circumlunar flights. This will be the flight control center, and also the reentry vehicle. Primary control will be on board rather than from earth, according to Low.

Major system developments needed for *Apollo*, as listed by Low, include attitude control system, G&C system, pilot displays, communication system, and power supplies.

A circumlunar mission, he has suggested, would require power of the order of 400 kw-hours with peak load of about 4 kw.

Both voice, telemetry communication, and possibly TV would be needed.

As for G&C requirements, those concerned take two distinct design approaches. Some believe in the need for a highly redundant hybrid system which would provide, basically, a multiple (possibly three) inertial stable platform, star trackers, and radio guidance.

The system then takes on the appearance of a *Polaris* submarine navigation system. However, its proponents believe it need not be nearly as massive or as complex.

The radio guidance would be flexible enough to accept control inputs from earth at the beginning and end of the journey. It might also be desirable to employ radar terminal homing from midcourse onward.

A digital computer can be employed to fully integrate all the control inputs, perform continuous calculation to refine the data, and directly or indirectly implement control with necessary commands.

The second approach is much less complicated. The primary guidance would be a sophisticated (but not necessarily newly developed) inertial system with another simpler inertial package for backup, as in *Dyna-Soar*. A celestial tracker would provide corrective data and radio would be used for altimetry measurements only.

It appears that the all-inertial versus radio-inertial argument in missilery has moved into space.

With the recent decision to employ a nearly-ballistic *Apollo* configuration (lift-to-drag ratio from 0.4-0.7) the control system will be primarily reaction-type. But NASA has indicated on all its re-entry vehicle configurations the inclusion of aerodynamic control surfaces. These will provide some small degree of maneuverability after entering the atmosphere.

Thus, the control system will have to provide for both reaction and aerodynamic controls. Such a system then

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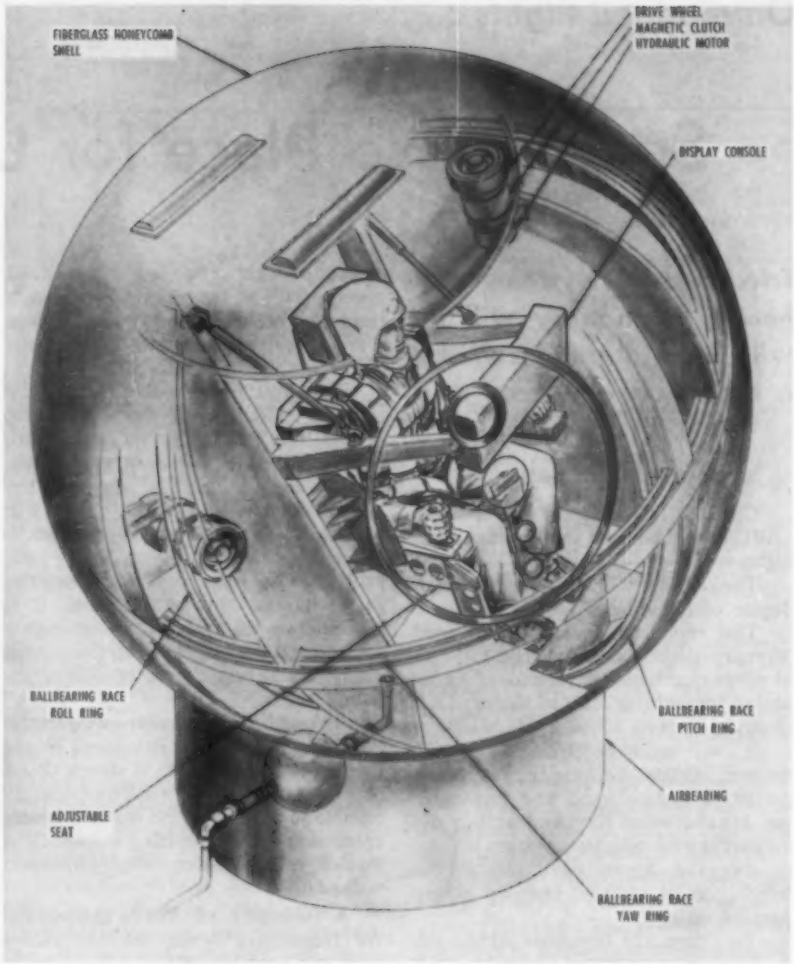


RIGOROUS GUIDANCE AND CONTROL training will be possible when Norair Division of Northrop Corp. delivers this flight rotational simulator to the Air Force School of Aviation Medicine. Ten-foot fiberglass sphere can rotate up to 70 rpm on yaw, pitch and roll axes. Air-bearing or "ground-effect" support of the simulator sphere and the ball-bearing support of the steel rings allow rotation with little resultant friction, and thereby simulates the frictionless environment of space.

On manned flights . . .

Space Is No Place for Untried APU's

Tried and true systems with heavy redundancy will fly with man to minimize risks; a report on advanced R&D

by William Beller

OBSOLETE auxiliary power units (APU's) will be used for manned space flight.

The APU's will also have a high degree of redundancy.

This was true during the manned *Mercury* flight, where nearly 150 lbs. of silver-zinc batteries redundantly connected formed the heart of the capsule's electrical system.

It will also be true for future manned flights, because an astronaut prefers a system aged and proven in use. He also wants it redundant, because no matter how reliable a system is there is always a degree of unreliability—which can be reduced only by having parallel systems.

Therefore, the advanced APU's will be flying only on unmanned vehicles. It will be years before such APU's become mellow enough to be used in a manned system. This is the reason for today's emphasis on new and exotic power sources—so that they will be ready for man when he needs them.

Even by 1965, probably none of the modern APU's will be sufficiently proven out. Thus, a National Aeronautics and Space Administration scientist working on APU's says that the *Apollo* manned spacecraft—which will require an average power of about 3 kw and a peak of about 5 kw—will probably use solar cells with batteries as the power conversion system. It is well known that solar cells are highly reliable and can be strung up in a circuit giving nearly any degree of desired reliability.

Although a 3-kw solar-turboelectric APU will probably be developed before the *Apollo* flights, there is strong doubt that the early versions will be sufficiently reliable to be used in the manned spacecraft. Another dominating drawback is that a single system would have no redundancy.

• **Definition of APU's confused**—All functioning space vehicles, except passive repeaters such as *Echo*, require APU's to operate instruments, radio communications equipment and tracking beacons. This is true for both manned and unmanned flights.

For manned flights, there may be an appreciably greater need for power to control the spacecraft's internal environment. However, even some unmanned vehicles need to have their internal environment actively controlled—if by no other means than opening and closing shutters to allow heat to be appropriately radiated.

The definition of auxiliary power as being something less than primary or propulsion power and playing little or no part in giving thrust begins getting fuzzy when applied to electrical propulsion systems. For example, can the advanced version of SNAP 8—putting out 60 kw which could be directly used in an electrical propulsion system—be called an APU? The semantics becomes even more pointed when later nuclear APU's—expected to be able to put out 1000 kw within the present decade—are built to give thrust to unmanned interplanetary probes and perhaps to manned lunar spacecraft.

For surveillance and reconnaissance work, such as the *Midas* and *Samos* satellites will be performing, highly efficient and reliable APU's can be a matter of national survival.

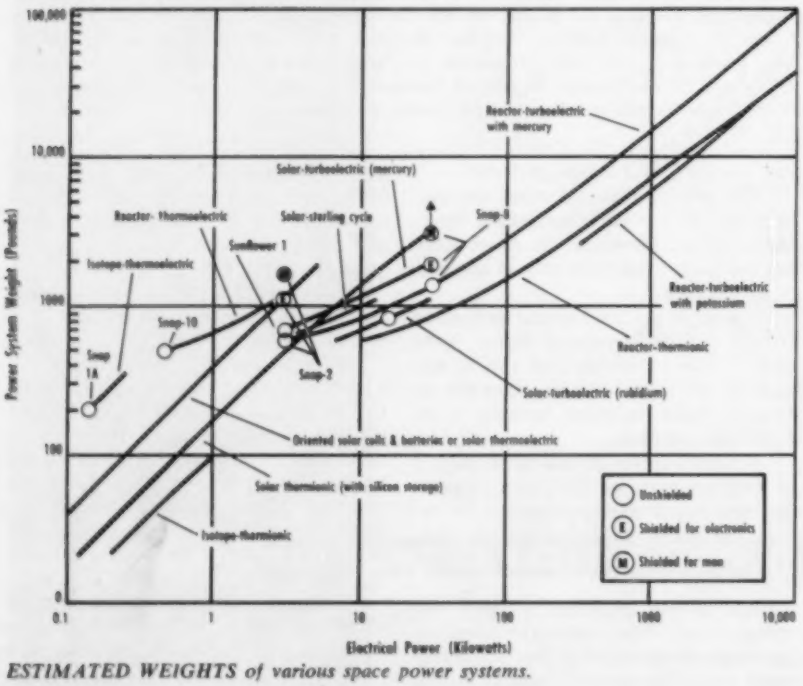
Similarly, national urgencies are involved in developing APU's able to operate offensive as well as defensive space military systems, able to power acquisition radar, computers, electronic countermeasures, and perhaps to initiate the launching of weapons themselves.

It is a truism, illustrated by the hydrogen bomb, that the military "needs" as much power as it can get.

Nearly all the space vehicles launched by the U.S. within the next several years will be getting their power from the sun. The *Mercury* manned capsule—because of its short flight duration—is an exception.

• **Needed power levels**—Through 1963, the vehicles will have power levels below 300 electrical watts. For the unmanned vehicles, this power will come from silicon solar cells feeding nickel-cadmium batteries.

The sun-orbiting satellite *Pioneer V* and the picture-taking satellite *Tiros I*, which is still transmitting, were outfitted with solar cells that developed



ESTIMATED WEIGHTS of various space power systems.

between 20 and 30 watts. The scientific satellites boosted by *Scouts* and *Deltas* had 10 watts, or less.

The *Nimbus* meteorological satellite will be getting an average power of 250 watts from a solar-cell array. For lunar-landing missions, *Ranger* spacecraft will be outfitted with more than 4000 solar cells mounted on panels which will develop a little over 100 watts.

The Venus and Mars probes, part of the *Mariner* project to launch unmanned spacecraft for early interplanetary missions, will need about 300 watts and 500 watts, respectively.

In 1965, NASA hopes to begin flight testing an electrical propulsion system composed of an ion or plasma thrust device powered by a 30-kw SNAP 8 nuclear-electric power supply.

Subsequently, NASA may call for electrical propulsion systems requiring power levels from 1 to 20 electrical megawatts. Chief use for these would be to power vehicles to explore the planets.

Every system is limited by wrinkles that must be ironed out during development time. NASA scientist William C. Cooley pointed out many of these during a recent panel conference at the California Institute of Technology; NASA Assistant Administrator Hugh L. Dryden and NASA scientist A. E. von Doenhoff discussed others during a meeting last month at the National Academy of Sciences. Their remarks provide some cogent observations about the state of the APU field as it affects NASA.

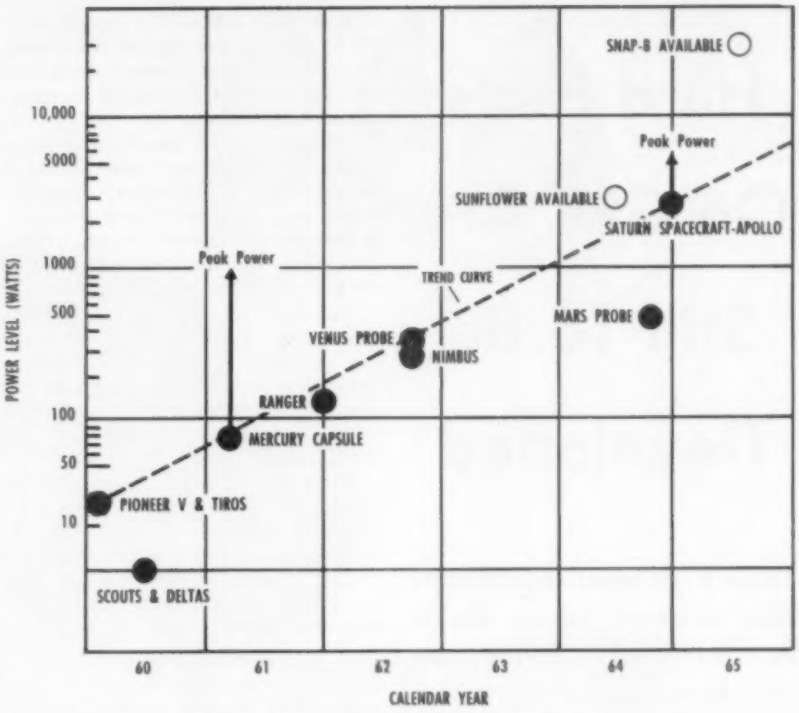
APU's get their energy from three sources: chemical, solar or nuclear. Just about every advanced system will use a combination of these sources.

• **Chemical power systems**—The silver oxide-zinc primary battery offers about the highest energy per unit weight—about 50 to 70 watt-hours per pound. Unfortunately, these batteries generate gas while they are being recharged, and consequently do not lend themselves to space work.

The only rechargeable battery that has been used for space work is the nickel-cadmium battery, which can be sealed. However, when it is being recharged by solar cells operating cyclically as in a low-altitude satellite orbit the battery's discharge must be severely limited if long battery-life is wanted.

The nickel-cadmium battery can store approximately 14 watt-hours per pound. If for adequate battery life the discharge must be limited to 10% capacity, which is not unusual, the effective specific battery weight is only 1.4 watt-hours per pound—a far cry from its capacity.

Cooley says that a battery with greater useable energy per unit weight would be very desirable and points out that the silver-cadmium battery appears to offer some possibility.



ESTIMATED ELECTRIC POWER requirements for NASA space missions.

• **Fuel cells**—A broad research assault on fuel cells is now going on, in order to get more watt-hours per pound than batteries can give. For example, the hydrogen-oxygen fuel cell has a theoretical output of 1620 watt-hours per pound of reactants. This is the highest of any electrochemical system now known. Thus, at 60% conversion efficiency, the fuel consumption is only one pound per kilowatt-hour.

However, some of the problems that must be solved before fuel cells can be used in spacecraft are:

1—Achieve long electrode life at current densities of about 100 milliamperes per square centimeter or higher, and

2—Provide for separating and removing the reaction product (water); and avoid mixing gaseous fuels into a liquid electrolyte under zero-gravity conditions.

The two most promising applications for fuel cells in spacecraft are:

1—The primary hydrogen and oxygen fuel cell, with cryogenic storage of the fuel and oxidizer for an output of 500 watts to several kilowatts and duration of several days.

2—The electrolytically regenerative hydrogen and oxygen fuel cell, for energy storage in conjunction with solar power systems.

• **Combustion-type APU's**—The *X-15's* APU is a hydrogen-peroxide open-cycle turbine system. Such a system has a low specific fuel consumption, below two pounds per kilowatt-hour, which makes it highly attractive for manned spacecraft requiring several kilowatts for several days. Possible applications include the *Dyna-Soar* and the *Apollo* circumlunar spacecraft.

To avoid the limitations imposed by temperature on combustion components, NASA through a contract with Thompson Ramo Wooldridge is conducting research on magneto-fluid-dynamic power conversion. In effect, an electrically conducting plasma is expanded through a magnetic field to generate electrical current directly. The current is extracted through electrodes perpendicular to both magnetic field and plasma velocity.

• **Solar power systems**—One of the big problems with solar cells is that they cost so much—about $6 for the basic cell or $10 for the cell assembly. Since a square foot of solar cells will put out about 10 watts and since there are 450 cells per square foot, a kilowatt of solar cells including $50,000 for batteries would cost about a half million dollars installed.

There are two approaches that can be used to reduce the cost. The first and more obvious one is to get more power per unit cell by better solar-cell design and production.

The second way is to use geometry

(Continued on page 102)

Hard Facts On GSE Are Still To Be Developed

There's general agreement that manned space flights will bring many brand new problems—here are a few

by Hal Gettings

ASK ANY GROUP of experts what will be required for support equipment for advanced man-in-space programs and their answers are apt to be more philosophy than fact.

All agree that as boosters and space vehicles get larger and more complex the problems of transport, handling, fueling and checkout exceed the state of the art. As spacecraft go farther into space, communications and control pose new problems.

But hard facts as to exactly how development will proceed in this vital area are difficult to find. The fact that GSE development should begin at the same time and run concurrently with booster and vehicle development is indisputable. In practice, however, such is often not the case. The basic configuration of the *Apollo* spacecraft, for example, is pretty well set within certain concepts. No one yet knows, however, how the vehicle will be transported to the launch site or how it will be hauled to the nose of its *Saturn* booster.

• **Transport**—The barge is certainly a Space Age anachronism—not the ultimate answer to the transport of large boosters and space vehicles. The long time involved in getting the vehicle from its fabrication site to the launch pad, as well as the hazards en route by water, is spurring researchers to look for better ways.

At present, two possible alternatives to barge transport have been suggested: on-site assembly, and the use of blimps or balloons.

Some thought has been given to assembly—and possibly even fabrication—on-site. Since, however, the final decision is yet to be made as to where future space launches will take place—from Canaveral, equatorial bases or perhaps even from seaborne launch sites—the question is somewhat academic.

Assuming that boosters and vehicles are manufactured at some location remote from the launch site, the problem of long-distance transport may be solved by use of lighter-than-aircraft.

Goodyear proposed last year that blimps be used to transport complete booster sections. It contended that blimps could be built large enough to handle the biggest boosters contemplated. The small landing-area requirements involved, allowing pick-up and delivery at almost any location, make the concept attractive.

An extension of this idea—using balloons towed by helicopter—has recently been proposed. Ramifications of such a technique have yet to be explored, but it appears to have somewhat the same advantages as the blimp method.

General Electric scientists, in their work on the *Apollo* feasibility study, found that the technique is workable. They point out the need, however, for developing special handling fixtures for use with air transport, whether the vehicle is shipped assembled or disassembled.

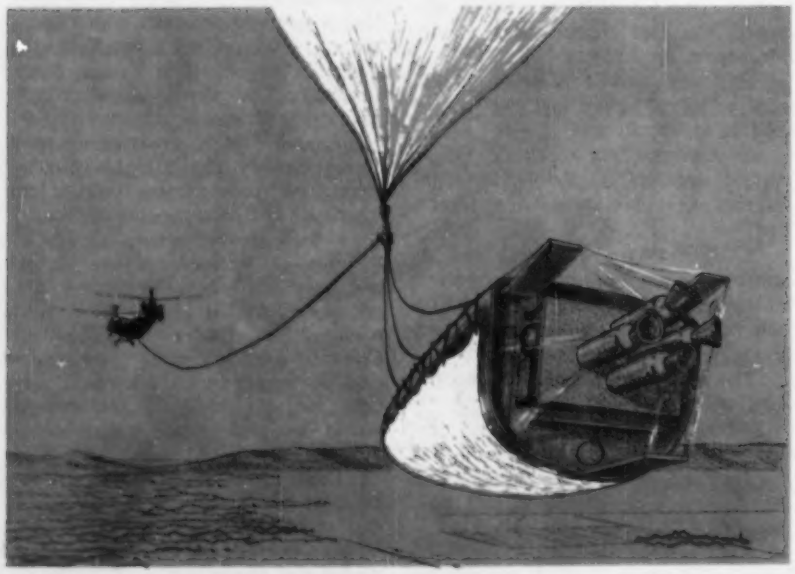
• **Checkout equipment**—The complexity and magnitude of the checkout job for manned space vehicles will require more extensive use of computers and automated countdowns. The limited ground "running time" of both sophisticated electronic systems and sophisticated man will require increased checkout speed—another case for the computer-checkout marriage.

Martin Co. engineers predict that specialized one-function computers will give way to greater use of flexible arrangements of general-purpose computer modules. And ground-support equipment will be designed to permit relatively inexpensive growth concurrent with developmental refinements of the flight system.

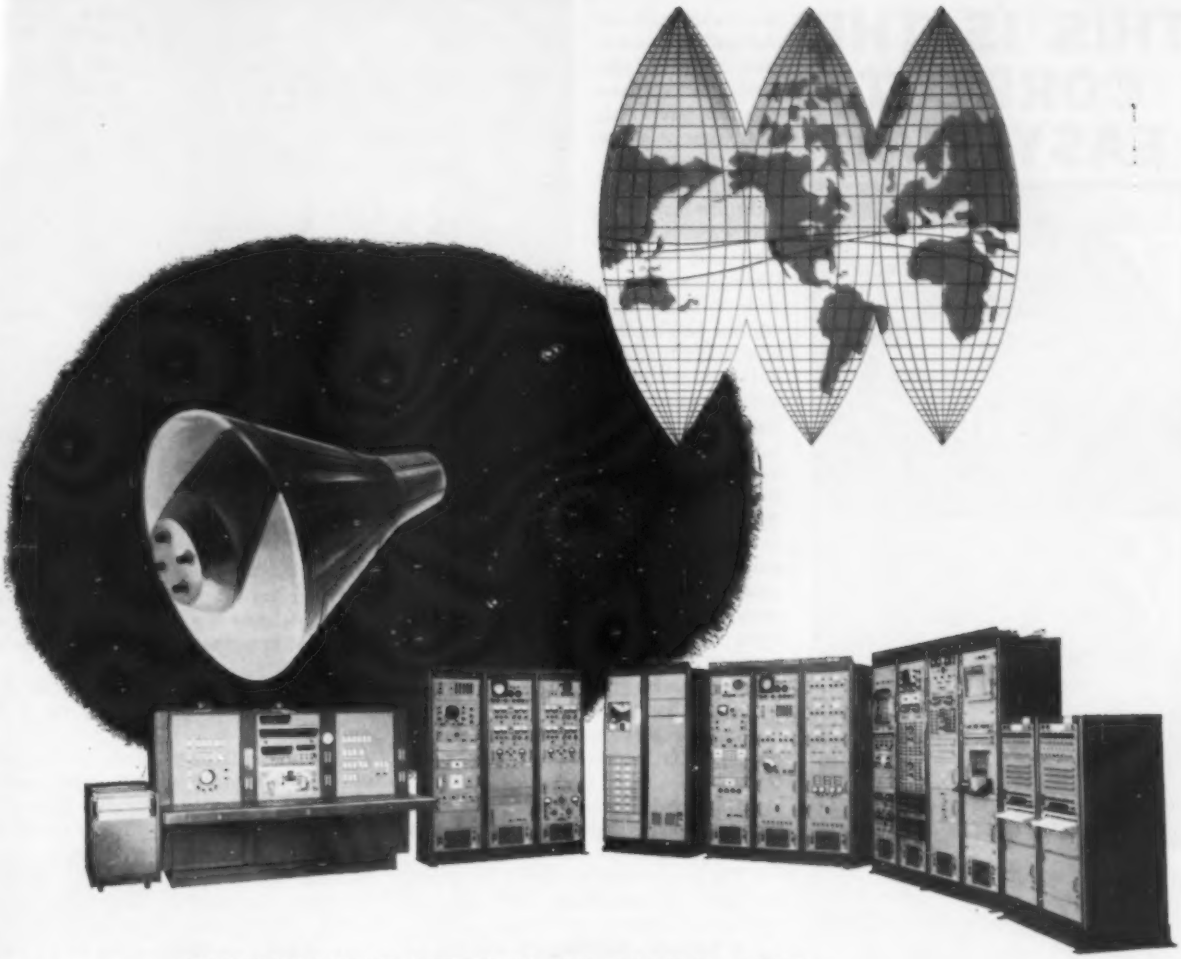
General Electric researchers back up the Martin idea. They say that the complexity of manned space systems, together with the expected multitude of changes which can be expected during development, requires modular checkout equipment with built-in flexibility.

In detailing a checkout procedure for a future manned system, GE says that the vehicle must be completely checked out before leaving the factory, down to black-box level. A duplicate checkout system will be used at the launch site.

One month before launch, there will



HELICOPTER-TOWED BALLOON may be the answer to transport of large space vehicles and boosters. Transport is a major problem in support equipment, and may have significant effect on techniques of vehicle construction.



CONGRATULATIONS TO NASA AND MERCURY ASTRONAUT ALAN B. SHEPARD, JR.

Bendix-Pacific as a member of the Western Electric industrial team, furnished the Telemetry Receiving Display and Data Handling Subsystems to the National Aeronautics and Space Administration for Project Mercury.

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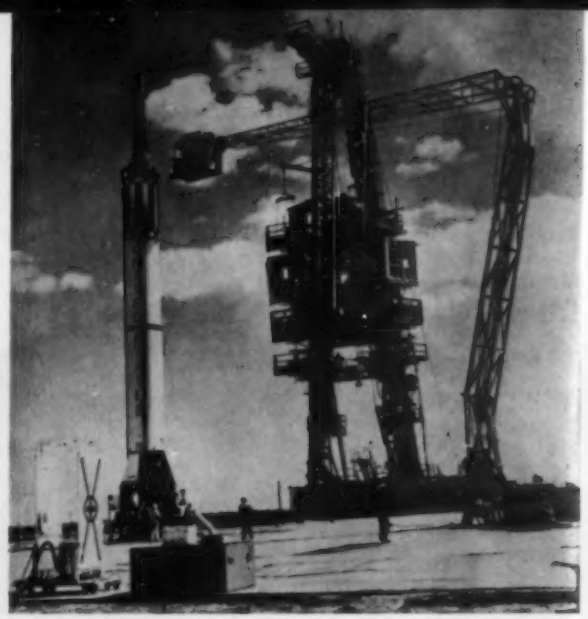
be a checkout on the pad for complete electrical and mechanical systems compatibility—with and without flight crews.

(The vehicle will be treated much like an aircraft and have assigned ground crew and several flight crews.) During this phase, flight crews will go through series of simulated flight sequences.

After the compatibility checkout the vehicle will be returned to hangar for major checkout. Then, three to four days prior to launch, it will go back to the pad, mated with its booster, and be given a pre-flight checkout with countdown by an alternate crew. Life-support facilities are then checked out and cabin atmosphere purged.



EVACUATION CABIN on 112-ft. mobile tower provides Mercury astronaut with emergency escape between gantry withdrawal and launch. Similar equipment for Apollo, requiring a tower with twice this reach, may demand new design approach.

The flight crew—after cabin atmosphere preconditioning—will take over two to three hours before launch.

The gantry will be moved away one-half hour before launch, and the system will go on internal power.

• **Ground handling**—Facilities for handling vehicles and boosters at the launch site will be decidedly more complex than present equipment. Some items will have built-in capability to accurately measure weight and balance of final stages and the complete vehicle. A single unit will be used to weigh and measure center-of-gravity eccentricity along longitudinal and radial planes.

Ground cooling requirements for *Apollo* have not yet been determined, but the system conceivably could include everything from thermal blankets to very large air-conditioning systems. In addition, pressurized gas servicing units will be needed.

The problem of propellant handling is seen as not much different from that of today's systems. Bigger tanks don't necessarily need bigger pumps. Some problems may arise in fueling the *Apollo* space vehicle's propulsion package if the decision is made to use liquid propellants.

Major headaches in fuel handling are foreseen, however, when future systems go to nuclear engines and auxiliary power units.

• **Tracking and communications**—Facilities for tracking and communicating with space vehicles of the *Mercury* and *Apollo* types are pretty much already in existence and pose no new problems.

As presently envisioned, *Apollo* will use the *Mercury* network with some additions and modifications. The net will be supplemented with field tracking radars improved in power, reflector size, etc., for increased range.

After the vehicle is beyond 1000 miles, NASA's deep space instrumentation facility (DSIF)—with 85-ft. receiving antennas in California, Australia, and South Africa—will be used to track and communicate with the vehicle. At least one of these stations—located 120 degrees from its sisters on the earth's surface—will have *Apollo* vehicle in sight at all times.

Pending outcome of a recent study as to technical and economic feasibility, NASA hopes to extend the capability of DSIF by construction of three 250-ft. antennas at the same locations. These would give a tenfold increase in information rate from lunar and interplanetary space vehicles.

Use of England's Jodrell Bank antenna—which tracked *Pioneer V* out to 22.5 million miles—is not contemplated in future space programs. For one thing, its optimum frequency (100-400 mc) is too low for more efficient space communication. For another, it would not be available for needed lengths of time.

Deeper-space flights beyond *Apollo* will put more of a burden on communications and tracking facilities. NASA says, however, that the increased requirements will be met by development and installation of higher-capacity facilities at existing tracking sites. Major

NASA'S DEEP SPACE Instrumentation Facility includes three 85-ft. antennas like this one at Goldstone, Calif. Tracking net may later be augmented by three 250-ft. antennas to support manned space flights and instrumented probes.

R&D effort will be in improvement of communications efficiency and data-handling techniques, and continued development of more sensitive receivers (paramps and masers) and higher-gain antennas.

Programed extension of capabilities to meet these new demands can, however, be provided by evolutionary development; no revolutionary jumps are anticipated, or needed.

The choice of radio frequencies for space exploration is one without severe limitations. The basic radio range equation allows a wide range of frequencies for space communications. Dr. Eberhardt Rechtin, DSIF director, says that the state of the art in electronics and interference characteristics will probably decide the final choice of frequencies. He concludes that the range between 1 and 10 gc appears to be best. International telecommunications experts have informally agreed on the allocation of the 2300 mc band for deep-space communications. ⌗

NASA Fills a Gap

A NEW OFFICE, to bridge the gap between study projects and development programs for advanced launch vehicles, has been established by the National Aeronautics and Space Administration.

John S. Attinello, who has been chief of Scout-class vehicles, will head the new group, which will be called the Office of Experimental Development.

The new office will be responsible for planning programs for the Reactor In-Flight test (RIFT) vehicle, which will be designed to flight-test the Nerva nuclear engine; orbital docking and rendezvous operations; and the test programs involved in developing booster recovery techniques.

The Experimental Development office will be part of NASA's Office of Launch Vehicle Programs, headed by Maj. Gen. Don R. Ostrander. Attinello will report to Col. Donald H. Heaton, assistant director for vehicles.

Vincent L. Johnson, the Delta vehicle program manager, will take over Scout vehicles as well.

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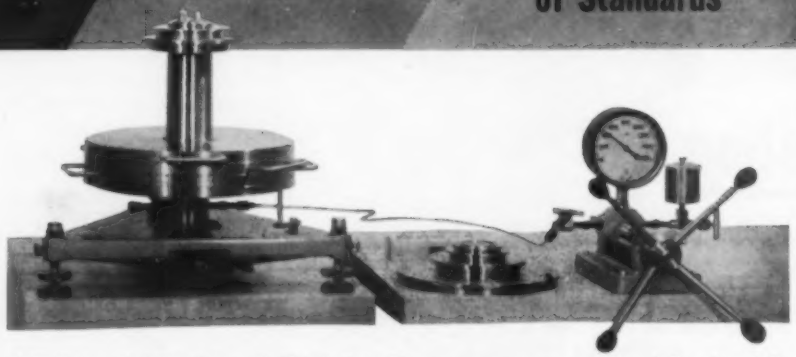

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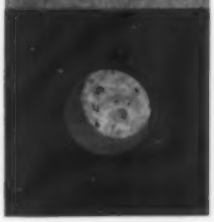

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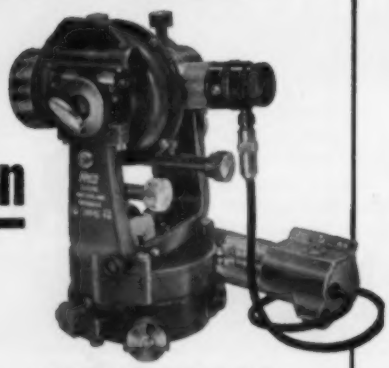

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AF's Pilot School Lacking Space Trainer

EDWARDS AFB, CALIF.—The Air Force will face two major problems next month when it begins its first full-scale course in Aerospace Research Pilot training at the Experimental Test Pilots School, AF Flight Test Center, Edwards AFB, Calif.

First the Air Force would like to have a "space trainer"—possibly some type of a ground-launched vehicle which could simulate launch, flight, re-entry, and other elements of a typical manned space flight mission in a compressed time period on the order of 10 to 15 minutes.

The second, slightly less serious, concern is an apparent lack of earth-bound simulation devices to provide basic knowledge of typical manned space vehicles. Some excellent simulators are being built, but nearly all have been designed for specific programs, rather than general application.

Maj. J. P. Seigler, assistant commandant and director of operations and training for the pilot school, and William Schweikhard, a research engineer on the school staff, say that the space trainer would remove training limitations imposed by the need to use the school's modified F-102 and F-104 aircraft. There are restrictions on the extent to which operational aircraft may be modified to provide re-entry simulation, weightlessness, energy management and landings with lift-to-drag ratios of 2.0 and 2.5:1. All these subjects and techniques will be included in Flight Training, one segment of the proposed four-part aerospace course.

• **No real answer**—Schweikhard noted that it was proposed some time ago that a two-place *X-15* be used as a space trainer, but he said this approach does not really provide the answer. In the suggested *X-15* design the instructor-pilot in the rear seat would be relatively "blind" during flight operations. Furthermore, lengthening the *X-15* fuselage to accommodate the second cockpit might pose stability problems whose solution might cost more than development of a "realistic" and simple space trainer—perhaps rocket-propelled.

An air-launched vehicle similar to that proposed for early *Dyna-Soar* testing might be another approach.

Other flight training in the "prototype" course will include time in the Wright Air Development Division C-131 used for for weightlessness studies.

School officials are quite frank in admitting that the first course will be

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a "cut-and-try" operation, but they hope they are on the right track. This is what brings up their second concern—simulation.

Simulation is a second portion of the four-part course. Schweikhard said it is a most important part of the training, despite the difficulty in determining and obtaining an adequate facility.

• **Stop-gaps**—For next month's initial class, two devices are being put together at Edwards. One is a cockpit simulator developed from a reclaimed F-102 cockpit. An analog computer, obtained as "surplus" from another Edwards facility which is updating its equipment, will be coupled to the simulator. The computer will act as an input, enabling a student to "fly" under a number of variables.

The second major simulation device will be the old "iron cross" used by the National Aeronautics and Space Administration in reaction control development. This will be modified to an air-bearing mount and fitted with simple compressed-air reaction controls. Cold gas jets, stabilizing wheels and other systems may be added later.

For other types of simulation, the school hopes to use a centrifuge, but it is not yet certain which one will be made available. Some tentative agreement has been made with the Navy to use the Johnsville facility, but the Edwards school is concerned over possible conflicts with other programs which might delay scheduled use of the centrifuge.

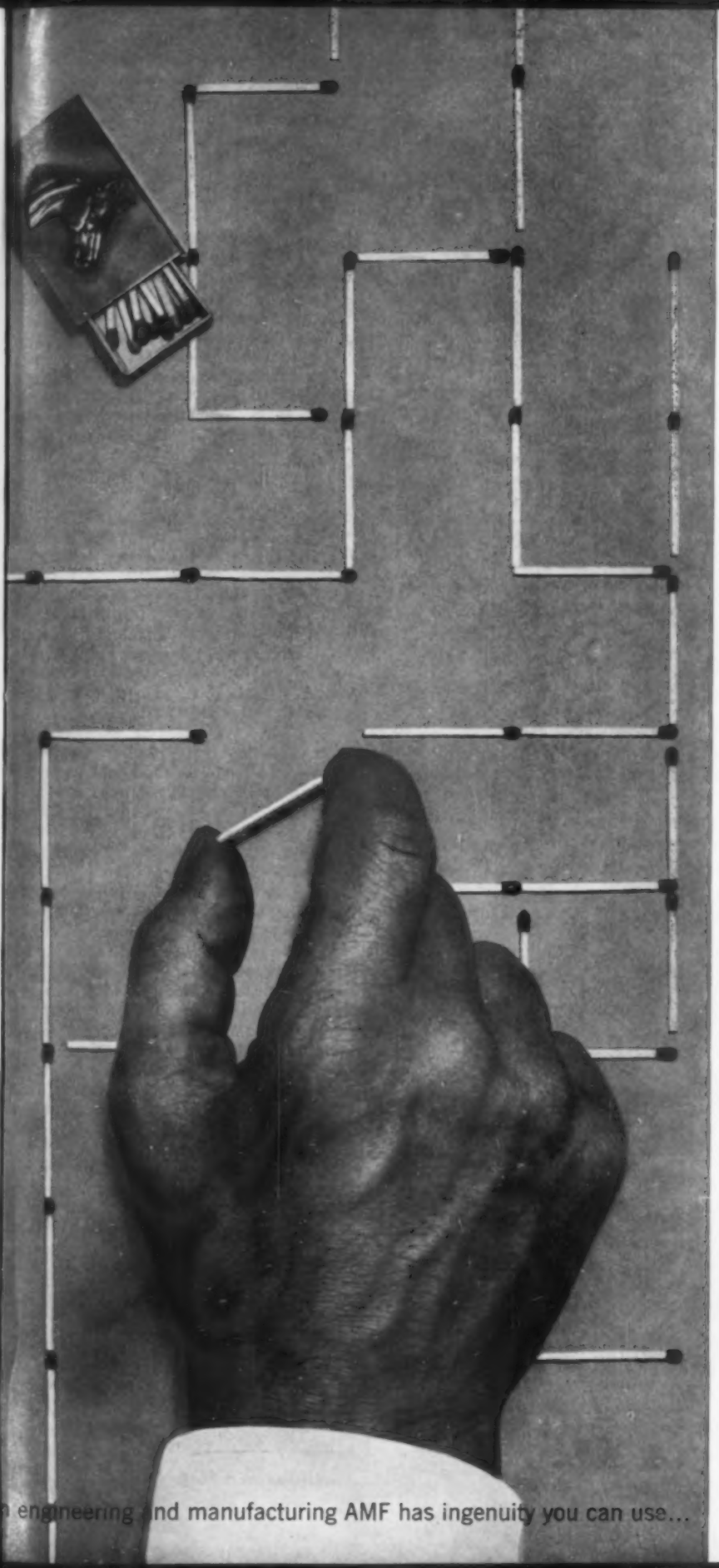
Both Seigler and Schweikhard expressed hope the program will be able to use the new centrifuge being built at NASA's Ames Lab. This would eliminate costs and time of travel to Eastern facilities. No firm agreement has been made with Ames, but school officials said they expect some cooperation.

In addition, Ames has several types of motion simulators which could be very valuable for the aerospace course.

The balance of the four-part course will consist of Academic and Field Trips.

• **In the classroom**—In the Academic phase, students will be instructed in basic subjects and areas beyond their current ability to practice and use. Subjects to be covered will include orbital mechanics, atmospheric and space physics, space navigation, guidance systems and guidance technology, launch and ascent trajectories, vehicle dynamics and communications—both voice and data transmission. Emphasis will be placed on the differences rather than similarities between aerospace operations and "normal" high-performance aircraft operations.

• **On the road**—Field Trips will consist of visits to various missile, rocket and aerospace firms where stu-



He designed a new interchange for radio traffic

This AMF engineer, part of an AMF-U.S. Army team, solved the problem of traffic delays and personal danger in manual re-connection of jumpers when interchanging R.F. transmitters and antennas.

His solution is a push-button-operated, coaxial crossbar switching system, using vacuum switches for circuit selection. A typical system consists of 4 transmitter inputs, 7 antenna outputs plus a dummy load, in a 4 x 8 matrix that can be mounted in a 19" rack. It can be controlled locally or remotely over any type of communication network having a bandwidth of at least 200 cycles.

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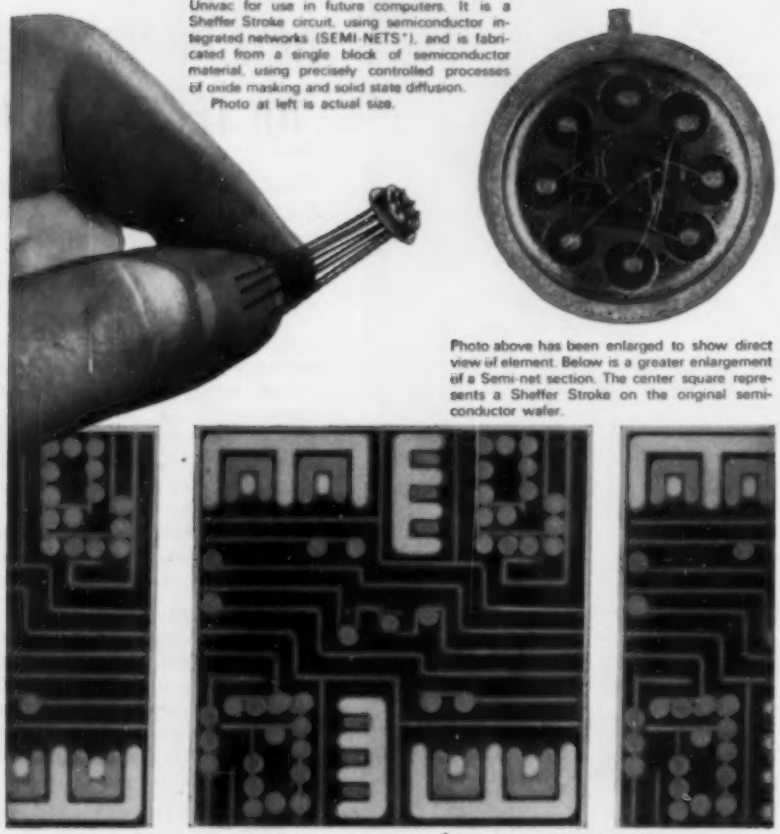

Developed by the Sperry Semiconductor Division, Norwalk, Connecticut, this logical element is currently being utilized at Remington Rand Univac for use in future computers. It is a Sheffer Stroke circuit, using semiconductor integrated networks (SEMI-NETS*), and is fabricated from a single block of semiconductor material, using precisely controlled processes of oxide masking and solid state diffusion.

Photo at left is actual size.

Photo above has been enlarged to show direct view of element. Below is a greater enlargement of a Semi-net section. The center square represents a Sheffer Stroke on the original semiconductor wafer.

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dents will receive briefings on special programs and current technology.

Students for the aerospace course will be selected from U.S. graduates of the Test Pilots School (the school also trains pilots from foreign countries). Following graduation, students will be sent to the School of Aviation Medicine at Brooks AFB, Texas, for special testing. It is planned to include reactions to g-loads and other types of high stress, barium tests and detailed physiological examinations.

To establish control data for the medical phases, several groups of graduates from past pilot classes of the school have been sent to Brooks AFB. Most of the biomedical studies are based, at the moment, on anticipatory-type examinations developed for the *Mercury* program. But the Air Force says that physical requirements for the course are "most tentative." Many probings will probably be dropped, and others added, as more actual data is gathered from additional ballistic or orbital manned flights.

• **High standards**—Little difficulty is expected in obtaining instructors. The first class, if present planning works out, will provide the cadre of instructors for future classes. Four of the first six students will be instructors from the pilot school.

Much of the written material has been developed from *X-15* test data. One of the most difficult tasks in planning background material is continuous scanning of pertinent literature. Close liaison with aerospace industries is expected to help in keeping all material current.

• **Toward specific jobs**—Much thinking behind the new course is based upon the Air Force's announced intent to place personnel in specific programs at the earliest possible time. With this approach, the service believes it can do a far better job in human factors and systems planning than is being done at present.

But it needs personnel, highly qualified and trained, for these assignments. Most recent such move is the assignment of three Air Force pilot-engineer officers to Boeing for the *Dyna-Soar* project—although individual pilots for the manned glider have not been selected yet, according to Major General John W. Carpenter III, AFFTC commander.

Training of such personnel is the school's mission. Personnel for *Dyna-Soar, Apollo* and other projects will almost surely receive their basic aerospace indoctrination at Edwards.

The school, in present planning, will not train for a specific program. It will, however, use all possible data-feedback from specific projects as material in future courses. ⌗

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Photos courtesy of Mount Wilson and Palomar Observatories.

Panama theory . . .

Have We One Good Reason to Colonize Ou

GE space analyst believes there are many reasons to go into space—and offers a striking theory

by Dandridge M. Cole

IN SPITE OF the successful suborbital flight by Alan Shepard, Russia still has a long lead in manned space flight.

What is the importance to the United States of Yuri Gagarin's orbital flight, and what is the significance of the Russian lead in space boosters and manned space vehicles? Is this just a question of national prestige—important as that may be—or are there perhaps other reasons why we should be seriously concerned over our present inferior position in the manned space flight race?

We cannot answer these questions without making carefully reasoned estimates of the probable long-range future progress of manned space flight. If manned flights into space in the next thirty years will be severely limited in quantity and in extent, then the importance of man in space can properly be considered in connection with its effects on national prestige and pure science, only.

If, on the other hand, Gagarin is truly the Columbus of Space as Khrushchev has prophetically named him, and if his flight is really the beginning of a new age of exploration and colonization, then far more is at stake in the space race than even our international reputation as the top technological power.

Is it possible that there are in space areas such as "Seward's Icebox" (Alaska) which may look very inhospitable and worthless now but could become extremely valuable in the future? Could we obtain some extraterrestrial real estate now for a finite though high cost which will be unavailable at any price in the future, when its value is perhaps more generally appreciated?

• **Ballet and plans**—To answer these questions we must put forth our best efforts in long-range planning, trend research, and state-of-the-art extrapolation. Although even our best efforts will not provide answers of high reliability, *they will provide answers* and these will be better than the pure guesses we often depend on in making major national decisions.

Unfortunately, Russia leads the U.S. not only in ballet, certain Olympic events, and space boosters, but also in long-range planning. While we used to scoff at their Five Year Plans, we now must note with chagrin their superior foresight in emphasizing ballistic missile development immediately after World War II.

Our present inferior position in long-range missiles is the direct consequence of the unimaginative and *incorrect* estimate of the importance of ballistic missiles which we made in the 40's. We escaped disaster in spite of our lack of foresight (we hope) only because of an unprecedented rapid development of ICBM's and a fortuitous breakthrough in large solid rockets.

We are in serious danger of making the same mistake again with man-in-space. It is essential that we assess the probable future of space flight with full realization that excessive conservatism and technological caution may be even more dangerous than overoptimism; that technology will grow at least as fast in the future as in the past, and that new scientific and engineering breakthroughs are inevitable.

No better evidence of our excessive engineering conservatism need be considered than the fact that *all* of our major parallel weapon developments have been successful. With a reasonable factor of risk some should have turned out to be impossible! (Note in particular the *five successful* methods for separating fissionable material under the Manhattan Project, *Thor-Jupiter, Atlas-Titan*, etc.)

Then what is a reasonable estimate of the long-range future of man in space? Is it reasonable to talk about bases or colonies on the moon and the planets or are such things just romantic nonsense?

• **Extraterrestrial colonies**—Colonies on the moon and the planets are *sense* rather than *nonsense* if three conditions can be satisfied. These are: (1) the bioastronautic condition, (2) the economic space transportation condition, and (3) the desirability condition.

These might be called the necessary and sufficient conditions for establishment of extraterrestrial colonies, since it is necessary that all three be satisfied in order to establish colonies, but they are sufficient because nothing else of major consequence need be considered.

The bioastronautic condition needs little discussion beyond a brief description, since it is generally accepted. It states simply that man will be able to live and work safely in the space environment. We will eventually learn to protect men from radiation, meteorites, temperature extremes, prolonged low gravity, etc., if such things prove to be serious hazards.

The low transportation cost condition is not quite so generally accepted, perhaps because the studies on future low-cost space systems have not had adequate distribution.

Obviously, colonies on the moon and the planets would be economically unattractive if payload boosting costs remained at their present high levels of several thousand dollars per pound in orbit. However, there are excellent reasons for believing that these costs will drop drastically in the next 20 to 30 years. It should be noted that there is no disagreement on this point among those who have made and published careful studies of the future space travel cost question!

We can expect in the next 20 years the direct operating cost of soft landing one pound of payload on the moon (Fig. 1) will drop from something on the order of $5000 in 1965 to $500 in 1970, $50 in 1975 and $5 in 1980. At this point the indirect operating costs will become an important factor and the

ize Outer Space?

curve of total cost will start to level out.

• **Energy misconception** — At the present time, it costs close to $5 per pound to fly to Australia. A large part of this cost (about 75%) is "indirect"—employee salaries (40%), materials, supplies, services, food, etc. These costs should be approximately the same for the moon flights and will not change much with time.

Direct operating costs are primarily those of the vehicle and the propellants. They represent the necessary investment for satisfying the energy requirements.

It is commonly believed that the energy requirements for space flight are far beyond anything ever attempted in earth transportation systems. This is one of the most serious misconceptions concerning space flight. Actually the energy required for a round trip to the moon is no greater than that for a round trip to Australia!

We have then an engineering problem of designing efficient and economical space systems which will perform as well in space as our present systems perform on the ground or in the atmosphere. We need larger vehicles which can be recovered and reused, and we probably want to use nuclear propulsion for at least part of the flight.

Some of the systems which have been proposed for very low-cost space travel are the *Rita* nuclear vehicle—Douglas, *Orion*—General Atomic, *Aerospace Plane*—USAF, and the contained nuclear explosion system proposed by the writer. There are also a number of other interesting possibilities which could almost certainly lead to low-cost systems if selected for development.

Of course, low cost alone will not bring about colonies on the moon. There must also be a good reason for establishing the colony. But note that only *one* good reason need develop, and this reason might be in any one of a number of different categories.

Some of the more important general categories in which we may find this major motivating force are:

(1) The challenge—adventure—men against nature category.

(2) Racial survival (if something happens to the earth like an all-out war).

(3) Science—the possibility for major scientific breakthroughs on entering new realms of nature.

(4) Economic—new sources of raw materials when earth supplies are depleted by exploding population.

(5) Military—retaliatory forces with reduced base vulnerability and increased warning-decision-reaction time.

(6) Social political—the possibility for growth of our culture through long-range colonization of new worlds.

This is only a partial list of reasons for colonies in space. There are many others. And remember that we only need *one* good reason!

• **The Panama Theory**—The Panama Theory can be summarized in one paragraph.

There are strategic areas in space—vital to future scientific, military, or commercial space programs—which must be occupied by the United States, lest their use be forever denied us through prior occupation by unfriendly powers.*

This is simply another way of saying that the history of exploration and colonization of the western hemisphere, Africa, and Australia, will be repeated in space.

No one can prove that the Panama Theory is true at this time, but the important point is that it *could* be true. Even if its probability of truth is quite low we should make sure that our space program represents adequate "life insurance." Most analysts agree that an all-out war is very unlikely; yet we spend billions on warning systems, air defense, etc., which do not help to pre-

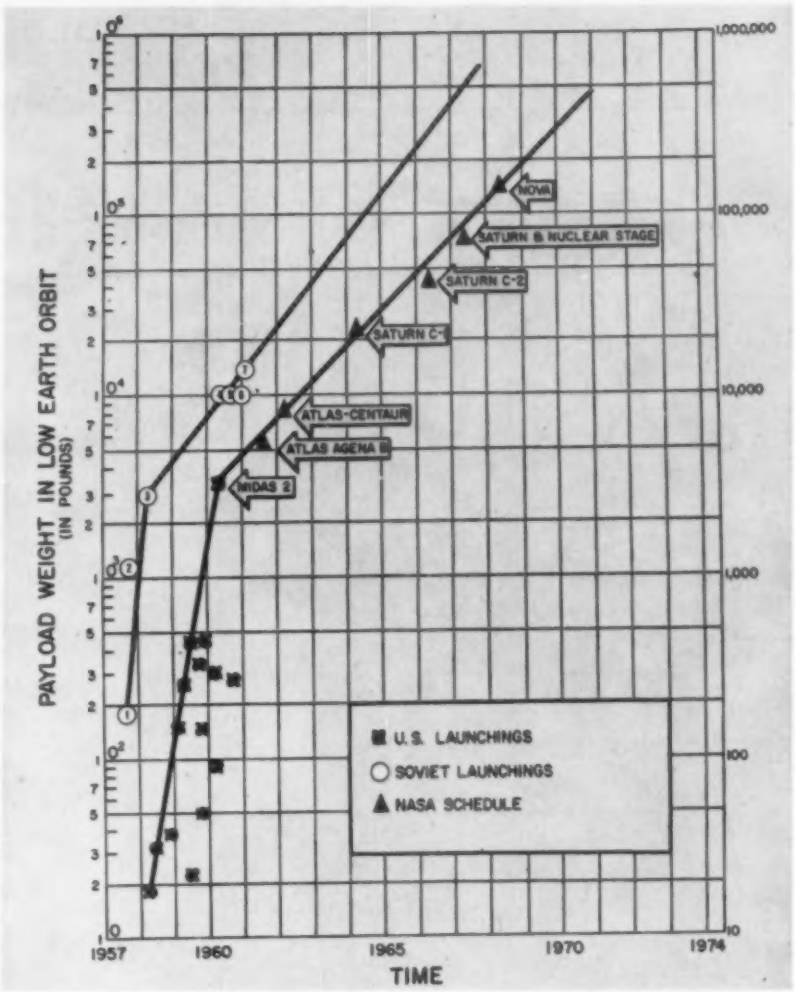

FIG. 1 Russia will widen "Booster Gap" if rocket development rate continues. Note straight line growth from Sputnik 4 to Sputnik 7.

* *The word "forever" is used in the sense that a criminal who is imprisoned for life is deprived of his freedom to roam the earth "forever," even though he is not in jail for an infinite time.*

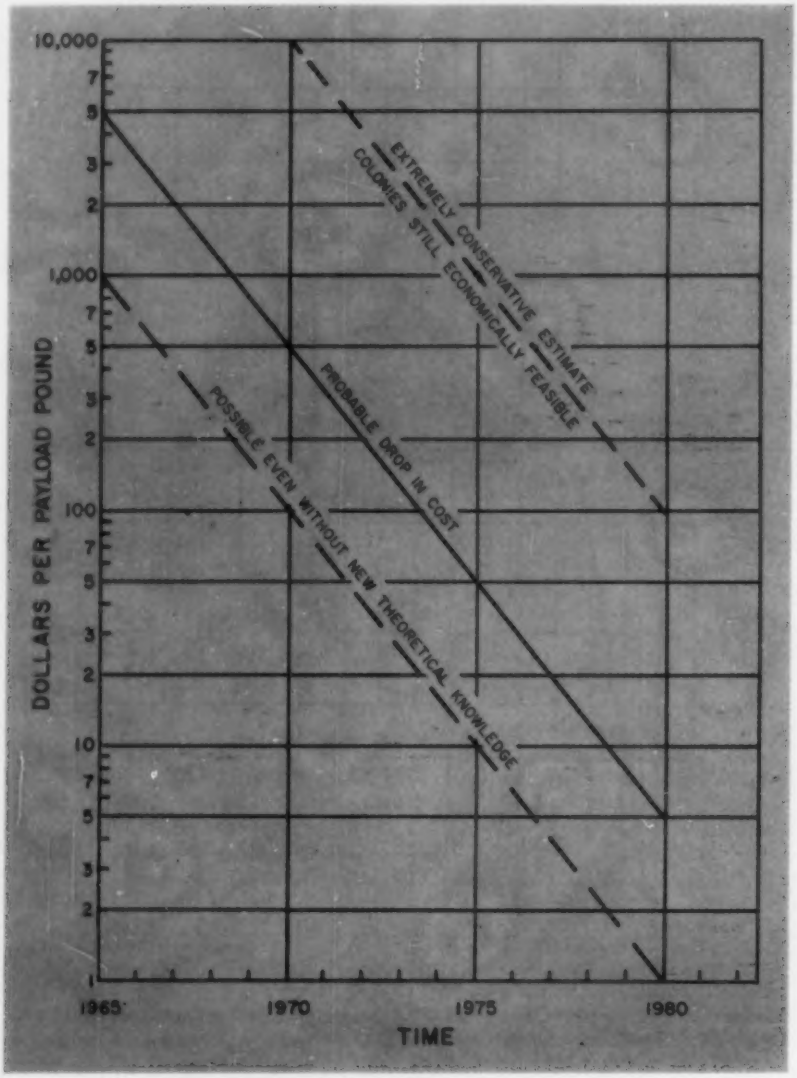

FIG. 2 Sharp drop in payload per lb. costs are expected in next 20 years. Reason: energy requirements are really low for moon trip.

vent war and will only be of value in the unlikely event that war occurs. Likewise we should spend enough to at least match the Russians in space and preferably outdistance them, to counter even a small probability that they might gain some decisive advantage. But is it just a small probability?

There are only two serious questions about its truth, if the preceding argument for extraterrestrial colonies is accepted.

These are the questions of "preferred" or "strategic" areas and the question of continuation of the power struggle.

Suppose that mankind does establish colonies on other planets. Will this be done in a framework of friendly cooperation with other nations, or will competition be the rule as it has been almost invariably in the past?

It is often noted that Russia has cooperated with us in the Antarctic. This is true. But there are three points to remember in this connection. (1) We were there first. (2) The Antarctic is not a stepping stone to any new worlds. (3) The Antarctic is, superficially, relatively homogeneous—one big icebox. The competition may start when the key areas are discovered!

In short, the Russians cooperate when it is to their advantage to cooperate. If they discover a rich source of high-grade uranium in the Antarctic, will they offer to share it with us? We are on roughly equal footing with Russia in the Antarctic and reasonably well equipped to compete if competition proves necessary. Will we be so advantageously situated on the moon?

The remaining question is that of preferred or strategic areas. Are there any in space, or is all the extraterrestrial real estate as relatively homogeneous as the Antarctic now appears to be?

Almost certainly the key strategic areas of the moon and other extraterrestrial bodies are yet to be discovered, but it has often been noted that the moon itself can have a unique value in the future conquest of the solar system.

The moon may be—in a sense—a Panama Canal.

Because of its low gravity, and perhaps its lack of atmosphere, it can become an excellent refueling station for vehicles making longer space flights. Note that this depends on the availability of propellant materials on the moon. There would be no value in carrying earth-manufactured propellants all the way to the surface of the moon for refueling Mars-bound space ships!

However, it is easy to show the advantage to a military commander of a fleet of nuclear deep space patrol ships if there's a source of liquid hydrogen on the moon. Likewise it would be much easier to refuel a nuclear vehicle bound for Mars or beyond, with hydrogen from the moon than from the earth.

Of course this depends on our finding a source of hydrogen or some other expellent material on the moon. Only two or three years ago the general scientific opinion was that there was no hydrogen or water on the moon.

• **Water on moon**—Now, after more careful consideration, a number of scientists have predicted that water in the form of water of crystallization in the lunar rocks is almost certain to be found. One estimate indicates that as much as one percent of the lunar surface may be water.

While this is far less than the percentage of water on the earth, it nevertheless represents a very considerable tonnage. Harrison Brown, Harold Urey, V. A. Firsoff, I. M. Levitt, Zdenek Kopal and Thomas Gold are among those prominent scientists who have very recently predicted that water in substantial quantities would probably be found on the moon.

The moon is a big place, and a Russian base complete with propellant-manufacturing plant would not necessarily preclude a similar operation by the U.S. The questions here are the availability and distribution of the best-grade hydrogen ores (not necessarily water) and the Russian lead in establishing moon bases.

Suppose that the Russians land on the moon five years ahead of the U.S. In this period it would be possible to establish several bases and stake out a claim to the whole moon. Of course, they would say that the moon was the property of all men and they were only holding it temporarily. And of course, the state will someday "wither away"

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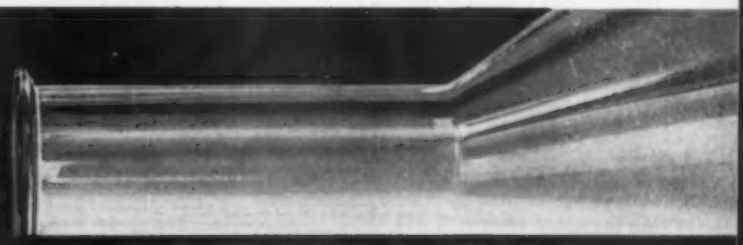

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In the meantime, however, any attempt by the United States to land on the moon would be declared aggression and our space ships would be shot down.

With only a two-year lead, the Russians might take possession of both the lunar poles—the most likely place to find water in the form of ice. Obviously, there are many other materials and natural formations (caves?) which are more likely to be discovered by the first ones on the scene. It is important that we do not give Russia a possibly critical advantage in time by failure to compete in the space race.

Of course, some say that we are not behind Russia in the overall space effort and that it is only in the area of payload weight that they have a lead. Unfortunately, high payload weight capability is the first requirement for a successful manned space flight. And in both these areas they obviously have a very substantial advantage.

• **The Booster Gap** — President Kennedy was recently quoted as saying "regardless of how much money we spend on *Saturn*, we are still going to be second. . . ." This is not immediately obvious, since *Saturn C-2* is being designed to orbit 45,000 lbs. of payload as compared to the 14,000 lbs. payload of *Sputnik 7*. Why won't this three-to-one advantage put us in first place?

The answer is that *Saturn C-2* is not scheduled for operation until 1966 and that, regardless of how much money we spend, we cannot advance this date to earlier than about 1964. However, 1964 is only three years away. Is it reasonable to expect that Russia will increase its payload capability by a factor of three in only three years?

Unfortunately, Russia may do considerably more than that. It is possible, even probable, that by 1964 they will have the capability for boosting 100,000 lbs. of payload into orbit.

Growth curves for U.S. and Russian orbital shots are pictured on Fig. 2. All the major Russian satellite launchings are indicated which contribute to an understanding of their payload capability. *Sputniks 8, 9, 10* and *11* would be off to the right of the curve and not important in this connection.

The same is true for U.S. launchings to date. Note that the curve is intended to indicate maximum capability in a given time period rather than average capability.

The curves also include some key performance figures from the 1960 NASA schedule and a possible extrapolation of the established trend in Russian launchings. Of course, the Russian curve represents actual launchings, whereas the U.S. curve beyond *Midas II* is simply a schedule—and schedules usually slip.

Of course, we do not *know* what advances in payload capability will be made by the Russians in the future. It is possible that their performance curve will level off sufficiently to strike the NASA schedule line in perhaps 1967, but this would be an extremely optimistic interpretation of the data. *Note that this graph was originally prepared in June, 1960, and that Sputnik 7 (January, 1961) confirms exactly the straight line growth curve through Sputniks 3 and 4.*

The NASA schedule of 1960 was considered to be a reasonable step-by-step evolutionary growth in booster capability. A development of this type in which each future step is determined by present status and past performance

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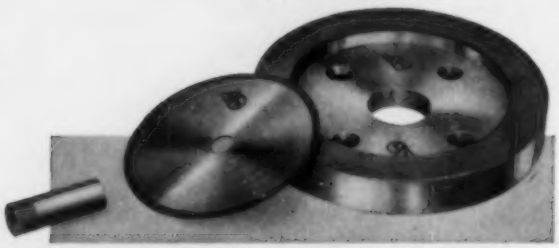

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naturally leads to a logarithmic increase as illustrated by a straight line on a semi log grid. Isn't it reasonable to assume that the Russian booster program, which has led ours by about two years ever since the late 40's, will continue on a similar, parallel, logarithmic growth curve?

The Russian schedule is believed to include a manned lunar landing by 1967. It would be reasonable to assume that in order to do this they would already have under development a *Nova*-like vehicle with early flights scheduled about 1965.

While the "step-by-step" schedule is hardly likely to close the booster gap, it would still be feasible to do so by the critical 1965-1967 period.

If we engage in a major effort to establish a moon base at the earliest feasible time, we can defend our military, scientific and economic interests in space and preserve our national honor. Even if the first manned lunar landing is Russian, we will quickly surpass them in the quality and quantity of our lunar colonization effort. ■

Panama Theory Poll

Dandridge M. Cole, a space program analyst in General Electric's Missile and Space Vehicle Department, has asked other persons in the space field what they think of his Panama Theory.

Cole polled 89 American Rocket Society Officers (34% replies), 75 high NASA officials (27% replies) and 17 editors of aerospace publications (35% replies) with the following results:

ARS—92% think the Panama Theory is a good reason for urgency and all responses average an est. 75% probability that the theory is true.

NASA—65% think it is a good reason for urgency. 56% probable that it is true.

Editors—83% in favor of urgency with 77% probability that the theory is true.

A study was made of the "non-responding group" by the Harvard Business Review in connection with similar questions on space flight and similar percentage responses. It shows that it is reasonable to assume the same distribution of opinions among the non-respondents as was found in the responding group for ARS.

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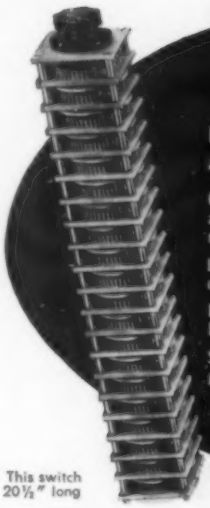

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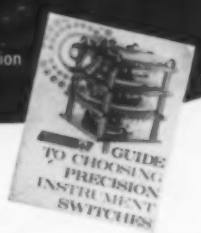

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Life Support

(Continued from page 46)

considerable research should be going into the long-term effects of breathing 100% oxygen at partial pressure. *Dyna-Soar*, and perhaps even *Apollo*, astronauts may have to be satisfied with this.

(The Russians apparently succeeded in getting sea-level pressure as early as *Sputnik V*, according to all available information.)

• **Food**—In spite of early talk about "algae biscuits," food in space will probably not be such an ordeal. The Aerospace Medical Laboratory at Dayton has been working for years on setting up low-weight, high-acceptability diets. Space dieticians now estimate that it will be possible to carry as much as a year's supply of food at a weight cost of about a pound a day.

Some new twists in refrigerating food will make it possible to carry fresh food for months. General Electric has mapped out complete feeding plans for journeys of almost any length with some unique refrigeration concepts. The company holds a contract for Project *FROST*, from the Aeronautical Systems Division, AFSC.

The Whirlpool Corp. recently completed building a prototype kitchen for

FOOD: Big item in GE's vehicle concept.

three men for a two-week voyage. While it's unlikely anything of that size or weight (818 lbs.) will be flying in the '60's the work goes a long way in pointing up all the little details which must be considered.

Faced with the danger of people cooped in with rotting garbage for weeks, the company designed some highly effective antiseptic sprays and containers. The workspace and arrangement of articles is designed with all the efficiency of a Mrs. Galbraith.

• **Protective clothing**—Probably the biggest single problem in the 60's is designing a pressure suit in which the wearer can move comfortably. The *Mercury* suit although remarkable for its pioneer effort, will not allow the pilot to make repairs or do much moving around under pressurization.

A more advanced suit designed by International Latex Corp. for the Air Force has a good degree of mobility and can be worn outside the ship except in high radiation areas. It is designed for wearing only for short periods—for launch, re-entry and emergencies. But, in spite of improvements over other suits, it still takes several minutes to put on.

The ideal suit, of course, would satisfy a chorus girl for lightning changes and an acrobat for mobility. Good tactile sense in the fingertips will also be necessary.

Another suit under development which might advance the state of the art is General Electric's Space Cape. It is highly classified, but it is known that the requirements it must meet are very rigid.

• **Bioinstrumentation**—Another field that has advanced far in the last few years, although some glaring gaps remain. The first problem is laying down the meaningful measures. Is it important to know what the pilot's skin temperature is? Do you need to record his eye movements to tell whether he is getting sick at his stomach, or can he tell you himself?

Ideally, it's best to find out everything possible about him, then pick out what's important. But, as aerospace medicine expert Lt. Col. Charles Berry says, "He's only over you for so long—and you've got to decide if he's sick or

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well and what to do about it—and in a hurry!"

The Texas Instruments *Mercury* telemetry system relays the astronaut's temperature, respiration, rate, electrocardiogram and pulse, as well as the suit pressure, temperature, oxygen and coolant supply.

The Soviets also apparently have a workable encephalograph, ballistocardiograph and perhaps even a blood-pressure sensor. Many U.S. space medicine experts say that an EEG would be a great asset in forecasting trouble of a psychological nature. A ballistocardiograph, which measures strength of the heart's muscular movement, might tell if the astronaut's circulatory system was weakening because of prolonged weightlessness.

Blood pressure is universally considered a necessary measurement. The problem has been developing an instrument that would not hinder the wearer. A pressure-cuff on the arm is cumbersome. Pressure sensors on smaller areas —fingertips or earlobes, are not always accurate. There are problems in controlling an air source to inflate any pressure device.

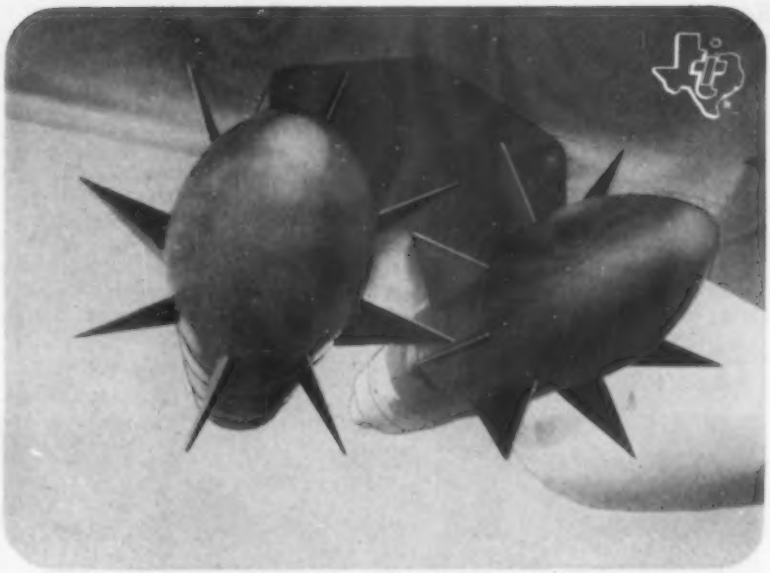
Pravda reported that for *Sputnik V* the Soviets performed pre-flight operations on the dogs and got blood pressure directly from an exposed cartotid artery. Whether the U.S. will go to anything this extreme remains to be seen. A number of companies—among them Boeing, Garrett, Spacelabs, North American, Bendix and Hughes—are developing blood-pressure sensors and several show promise of coming up with something in the next year or so.

Also in the wind are internalized telemetry systems which produce a clearer signal with less ambient noise. Spacelabs, Inc. of Los Angeles is the leader of this approach. A monkey with an implanted system is due to fly a ballistic trajectory in an *Atlas* "piggyback pod" this July. The animal has had the system inside it for a number of months now and has had no ill-effects.

• **Psychological aspects**—The problems are as complex as the people involved. Generally a "normal" man will always run into trouble the more he is shut off from outside contact.

Careful screening of astronauts will eliminate those who would tend to go to pieces easily or can't get along with others. Psychologists also recognize that useful tasks and frequent contact with the ground will help maintain a good mental condition.

Food will play an important part in mental attitude. In some group tests at the Aerospace Medical Laboratory the subjects did little else but sit around and talk about food. In every confinement experiment the crew ate more. ⌗



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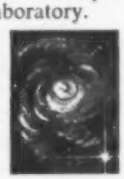

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Re-entry Approaches

(Continued from page 61)

sidered in a pre-selecting landing site, engineers such as R. L. Phillips of STL agree that atmospheric braking will be the chosen system for years to come. Today's rocket powerplants do not deliver sufficient performance, particularly in specific impulse and thrust-to-weight ratio, to make retrothrust an optimum method for significantly reducing the entry velocity.

The entry angle can be varied on low-altitude (i.e., low velocity) satellites such as the *Mercury* capsule and the *Discoverer* recovery capsule by applying appropriate reverse thrust from available solid-propellant rockets.

In the case of return from our moon or one of the planets, the entry angle can be controlled by present state-of-the-art guidance systems, entirely inboard or partially earth-located, the experts say. Of course, the ideal system would be independent of ground stations and could be used for entry through other planetary atmospheres.

Changing the entry angle can have the following effects:

• If the entry angle is 6 degrees or greater, the deceleration force on a ballistic-type capsule will generally be greater than 10 g's.

• If the entry angle can be kept small, for example, 1 or 2 degrees, the maximum deceleration can be held to levels which man can tolerate for the required duration.

• At the flat angles of 1 to 2 degrees, a small error in entry angle will result in only a small variation in maximum G-loads.

• At the typical entry angle for an ICBM, the nose cone can be subjected to a dynamic loading greater than 70 g's.

Reducing the entry angle to that compatible with man, however, increases the total aerodynamic heating and also makes landing at a selected point a more difficult problem for uncontrolled spacecraft. The thermal environment is largely caused by gaseous compression as the entry body rams down into the atmosphere. In other words, the air ahead of the body has to pass through the shock wave that is formed at the high velocity and, in the compression processes, heats the gas surrounding the affected surface.

There are two predominating types of heat transfer during this situation: (1) convective heat transfer caused by the gaseous compression and by viscous skin friction, and (2) radiative heat transfer caused by electromagnetic radiation from the hot, ionized gases behind the bow shock wave. Characteristics of the thermal environment are greatly influenced by vehicle configuration and trajectory characteristics.

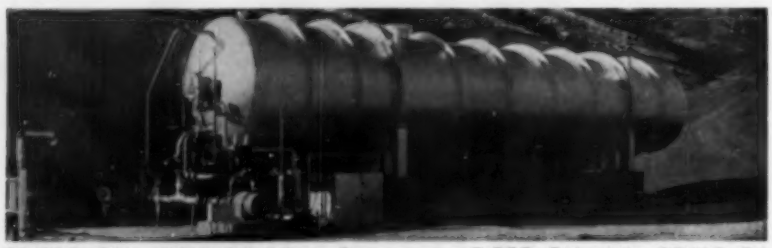
• **The entry corridor**—Another parameter receiving increased attention because of the recent industry activity in the field of manned space flight is the entry corridor.

The knowledge that a satellite-type spacecraft must be capable of operating over a spread of speeds and altitudes in relation to those characteristic of a nominal entry has resulted in adoption of the corridor concept.

There is no official definition for many of the terms encountered in "3-R's" technology. Entry corridor is generally agreed to be the range of entry conditions (angles and velocities) within which an acceptable entry is possible. This parameter is sometimes called the guidance corridor because of the very great dependence upon the spacecraft guidance system to approach the atmosphere of a planet at precise angles.

A. J. Eggers, Jr., of NASA, gave a more detailed explanation of the corridor concept in "Motion and Heating of Lifting Vehicles During Atmosphere Entry." It was co-authored with Thomas J. Wong, also from Ames Research Center.

If a satellite-type entry vehicle while moving at less than satellite velocity



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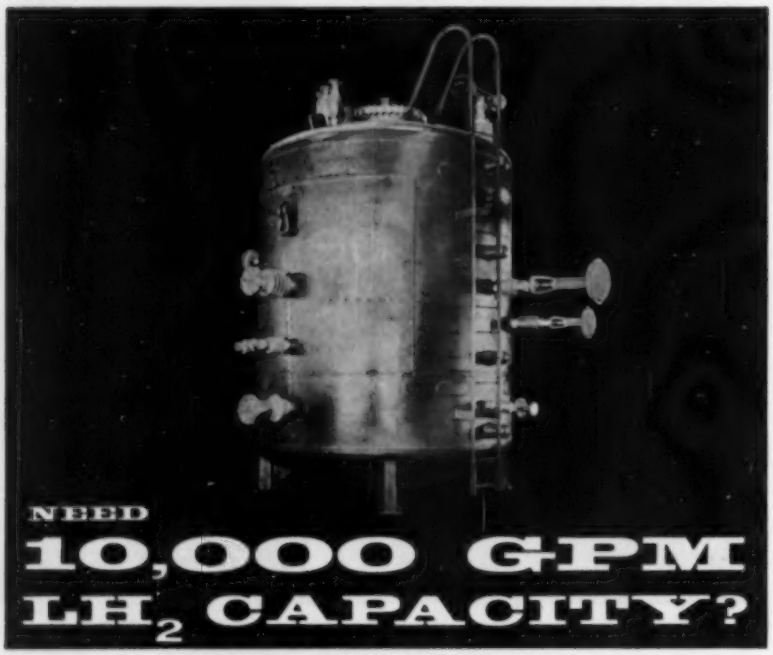

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passes through the upper boundary of this theoretical corridor or exceeds that altitude, the entry vehicle will be traveling too slow to sustain altitude and will be unable to check its descent before passing through the lower boundary of the same corridor.

If the same vehicle at the same approach velocity passes below the lower boundary as it enters, the vehicle will be traveling too fast to maintain acceptable deceleration loads and/or heating rates.

In the case of satellite-type spacecraft, the corridor boundaries (high and low) are defined as the speed/altitude limits outside of which the spacecraft should not be entering whether in the course of returning from orbit or making an emergency landing from an aborted boost into orbit.

If a spacecraft returning from cislunar or planetary space pierces the atmosphere at escape velocities above the upper boundary of the entry corridor, the vehicle will be unable to decelerate sufficiently to avoid exiting the atmosphere. It will proceed back into space for possibly vast distances and many days. This latter result is considered to be undesirable and somewhat discouraging to the returning space crew who have post-landing plans.

On the other hand if supervelocity entry leads to flight below the lower boundary of the corridor, the velocity will be so high that the landing spacecraft will be unable to avoid excessive heating and/or deceleration.

Eggers considers the approach from another planet along a corridor made up of an overshoot and an undershoot boundary, a region that is the difference between the virtual perigees of the overshoot and undershoot conics. These are fictitious conic trajectories which could be followed if the planet and its atmosphere theoretically did not have any size but were replaced by an equivalent point mass.

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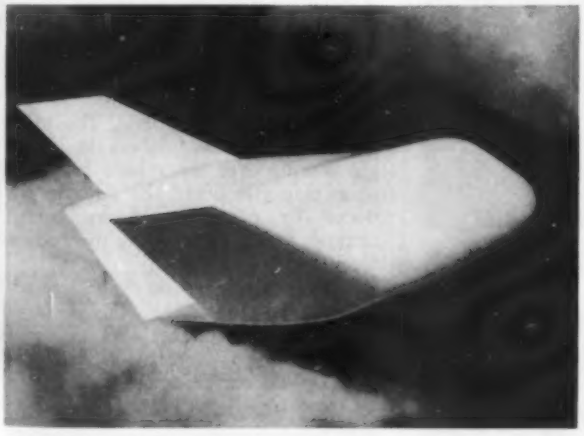
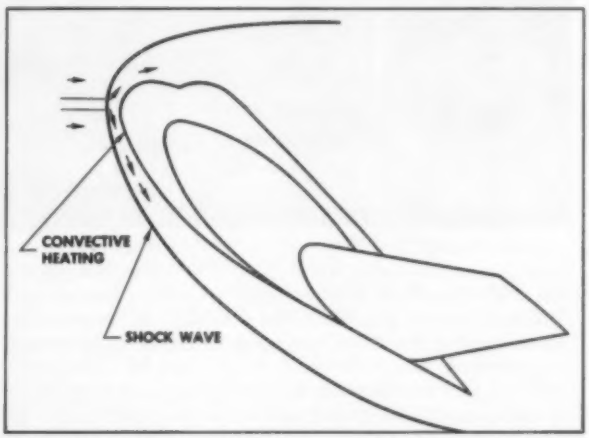
The larger the depth of the corridor, the less stringent is the requirement for guidance accuracy during the planetary approach.

• **Importance of the corridor**—Failure to approach the entry corridor at correct velocity, altitude, and angle can be disastrous. If a planetary spacecraft enters the atmosphere of a planet very steeply, say near 90°, then the dynamic loading can quickly rise to a peak of more than 400 g's. In contrast, if the atmosphere is pierced at 400,000 ft. (generally agreed to be the top of the sensible atmosphere) at less than approximately 4°, the vehicle will follow a grazing trajectory and proceed outward along a new and unexpected orbit.

All these statements can be summarized in a few words. The returning zero-type lift vehicle must be directed by a guidance system or some other arrangement to follow a precise entry angle found to be between 5° and 6°. This leaves a very tight corridor only about eight nautical miles in depth.



DOUGLAS MANNED re-entry vehicle model in position to begin landing maneuver after completing previous re-entry phases.



ATTITUDE OF the Lifting Re-entry Vehicle as it begins the transition phase in the upper atmosphere.

The narrow guidance corridor can be "opened up" by employment of one of several available techniques.

- The entry vehicle can be designed in a manner that permits its drag coefficient to be varied; a technique known as drag modulation.
- A vehicle can be designed and controlled in a manner that will produce lift.
- It is believed that an earth-entering vehicle can be designed to employ magnetohydrodynamic drag, taking advantage of the ionized boundary-layer air.

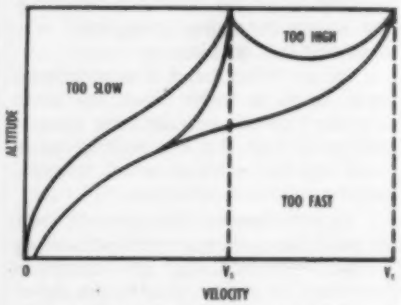
• **The drag-modulated vehicle**—Donald M. Waltz of Radioplane discusses drag modulation in some detail in his paper, "Design Criteria and Techniques for Deployment of Aero-Space Deceleration Devices." As Waltz points out, a constant value of deceleration rate can be obtained if the term made up of the density ratio divided by the ballistic parameter is held constant. The density term is the ratio of density of the atmosphere at altitude to density at sea level. The ballistic parameter, W/C_DA, has become a common term in re-entry technology. In it, W represents vehicle weight, C_D is the total drag coefficient, and A or A_c is the cross-sectional area on which C_D is based.

Lower values of the ballistic parameter for a vehicle entering the atmosphere will result in lower maximum heating rates and surface temperatures. Peak deceleration rate will be essentially unaffected by variations in this parameter.

Drag modulation describes a system where the drag area (C_DA) is continuously decreased as altitude decreases. The desirability of achieving rates of deceleration lower than those experienced during typical entry of ballistic nose cones is apparent. As the drag-modulated vehicle plunges into the atmosphere, it can be streamlined more and more by mechanical means to prevent dynamic loading from reaching more than a fraction of the unmodulated value.

If the drag coefficient can be varied by a factor of 10, the deceleration can be reduced approximately 60 percent.

• **The MHD-decelerated vehicle**—A few industrial organizations are seriously studying the feasibility of an advanced technique for increasing re-entry drag—the use of magnetohydrodynamic principles. It is known that a large portion of the boundary layer air flowing over an entering body exists in the ionized state. This condition results from the high-velocity, high-temperature, low-density flight regime in which the body is traveling prior to and during atmospheric entry. Ablation of surface material tends to increase this ionization.

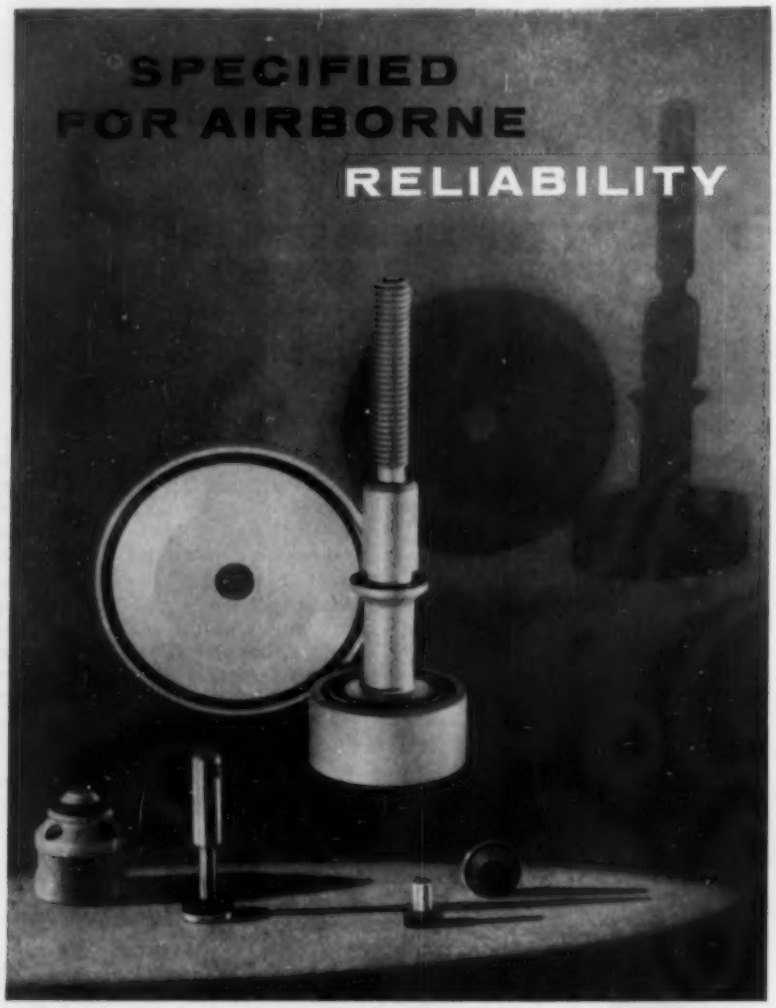


GRAPH illustrates Corridor Concept.

The ionized boundary layer will conduct electricity and can be forcibly shifted by a magnetic field. The MHD vehicle can slow and deflect the ionized gas flowing over the vehicle by means of a magnetic field. The field is produced by passing a heavy current through a ring surrounding the body at the appropriate location.

The electromagnetic drag force will result from giving the body a larger effective cross-sectional area as far as pressure drag is concerned. The shock wave would correspondingly be moved upstream and thereby would reduce the heat transfer rate.

Proponents of this concept are reported to be looking for a lightweight



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municipal power station that can be fitted into a spacecraft.

• **The lifting re-entry vehicle**—The entry corridor depth can be increased by employing negative lift along the upper boundary and positive lift along the lower boundary. The first alleviates exiting or climbing out of the upper atmosphere; the second avoids penetrating to too low an altitude at too high a velocity.

Thus the vehicle continues to travel at very high altitudes (i.e., in low-density gas) until it decelerates to the condition from which it can proceed to lower altitudes without developing great drag forces. A considerably wider range of entry angles is thus acceptable.

The linear tolerance on the guidance system corresponding to this technique is increased to approximately 80 nautical miles, compared to the 8 nautical miles previously stated. Of equal importance, a lifting vehicle can be used for a certain amount of maneuvering during flight in the terminal region to assist in landing at a designated field.

The Douglas concept, labeled "A Practical Manned Entry System," resembles a blunt delta wing; the vehicle incorporates a thick-wing, subsonic airfoil modified to satisfy hypersonic thermodynamic requirements.

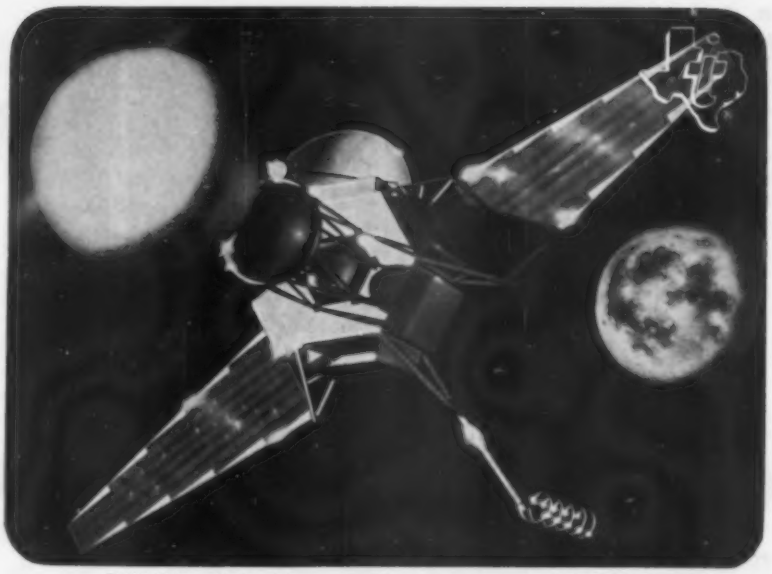
The thick wing was chosen to give the vehicle adequate subsonic flight characteristics and to reduce hypersonic heating. The wing section chosen has a profile similar to a forward-camber subsonic profile. The platform is best described as a modified trapezoidal which presents a blunt stagnation region at high angles of attack. A vertical stabilizer rises from each wing tip. The spanwise contour provides a small angle of effective dihedral for lateral stability at subsonic speeds.

A sharp trailing edge improves the control capability and provides better subsonic lift. Model tests indicate that a maximum subsonic lift/drag ratio in excess of twelve can be attained; a maximum lift coefficient greater than 1.4 was measured within the angles of attack of interest.

• **Entry of the lifting vehicle**—After the Douglas wing approaches the planet's atmosphere along a coasting transfer trajectory characterized by the particular mission, entry technically begins. At approximately 400,000 ft., aerodynamic braking commences.

The orientation given to the wing to obtain lift during entry must be carefully controlled to keep the dynamic loadings within the passenger's endurance while at the same time not subjecting the structure to unacceptable heating.

During interviews with Lowe, duPont and Gervais, M/R learned that altitude-controlling and maneuvering in



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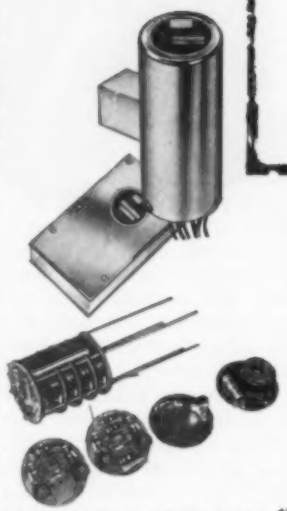

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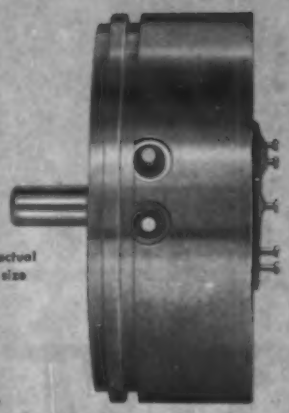

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the upper atmosphere and during the approach will probably be accomplished by some arrangement of fixed thrusting nozzles, perhaps similar to the *X-15* installation.

They found that their wing should be designed to enter the atmosphere at the angle of attack that corresponds to the maximum lift attitude—because the deceleration loads will be within the pilot's tolerance and the surface heating will be minimized at this orientation. The Douglas engineers analyzed four methods of placing the lifting vehicle on an equilibrium glide trajectory—constant-attitude entry, modified lift-modulated entry, two-phase injection entry, and an entry that makes use of a rolling maneuver—and selected the latter.

Prior to attainment of the equilibrium glide, the calculated trajectory is characterized by three distinct phases—entry, transition, and constant-altitude phases, in that order. During both satellite and planetary entries the wing is maintained at constant lift (maximum lift attitude) through the pullout altitude where maximum heat rate is encountered. Reductions in lift prior to this event will increase heating.

Consequently, the wing will start the transition phase at approximately 45 degrees angle of attack along a positive flight path angle of 0° to 2°. Next a pitch-down maneuver must be executed, reducing the lift to an eventual negative value, to keep the vehicle in the atmosphere if the entry is at planetary velocity. For satellite entries the pitch-down maneuver prevents phugoid oscillations.

The method by which the designers plan to decrease lift without heating both sides of the wing is the unique feature of this concept. By means of attitude-control jets (probably in an autopilot loop) the wing will be rolled about its velocity vector in such a manner that the total angle of attack (45°) along the flight path is continuously maintained.

By this rolling maneuver, the vehicle's effective lift in the vertical plane is reduced but the total lift is relatively unchanged. The deflection in lateral range would be accounted for in the landing prediction. The advantage of this concept is that only the bottom of the wing is exposed to hot gas flow and needs to be thermally protected.

The rolling maneuver is continued until a roll angle is found that causes the flight path angle to go to zero value at an acceptable altitude to initiate the constant-altitude phase. Here the purpose is to dissipate remaining kinetic energy at safe temperature levels until the velocity is reduced to a value where the equilibrium glide can be attained.

In maintaining constant altitude the vertical lift will need to be gradually increased as the vehicle's velocity de-

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creases or, in other words, the roll angle must be correspondingly decreased. The high total angle of attack is continuously held throughout constant-altitude flight, ending with the roll angle again at zero. Now all lift is confined to the pitch plane.

When this condition occurs the wing has been decelerated to less than satellite speed and will start to descend again, this time along an equilibrium glide path.

As the wing progresses into the glide phase, velocities of 15,000 to 22,000 ft. per sec. are anticipated. Therefore, the maximum lift orientation must be held as the vehicle descends through the atmosphere to a point where a high angle of attack is no longer mandatory for thermodynamic protection. Then the remaining energy can be used to obtain additional range if needed and to execute the landing maneuver.

There are many concepts of lifting re-entry and planetary entry vehicles under study and, in a few cases, in test. It is too early to foresee what configuration will follow *Dyna-Soar*, the first space glider. ⠿

Guidance & Control

(Continued from page 73)

will have to be built and tested.

• **Simulation results**—Martin-Baltimore has performed extensive simulations for *Apollo* and for determining manual controllability of spacecraft for space rendezvous. Its system duplicates all guidance aspects of space travel, and the company has to date accumulated millions of miles of simulated flight. Similar programs have been conducted for *Apollo* feasibility studies by General Electric, Convair, and others.

Since the *Apollo* vehicle will be under the complete control of its crew, every aspect of manual control has been simulated.

In the rendezvous studies, Martin said results have shown there is no doubt that even with a relatively simple, lightweight guidance system space rendezvous can be accomplished. The controls in the simulator, which in function and performance closely emulate those actually to be used, permitted velocity control down to increments of 1.5 ft./sec.

Other simulations have proved the feasibility of orbital injection, midcourse guidance, re-entry and landing at a designated point, and degree of radiation hazard with varying protective shielding.

A major point is this: Based on a variety of inputs to M/R from leading manufacturers, the consensus is that no breakthroughs are necessary in techniques or equipment for G&C for

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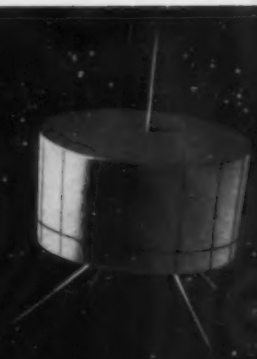

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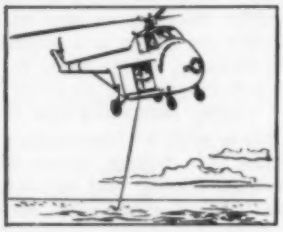

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manned orbital or circumlunar flights. There will be development problems—as in any major prototype system, but now it is a case of building and integrating with present hardware, not a matter for researching.

• **Current R&D**—The stakes are high in this race by manufacturers to secure a winner in each new space event. As far as G&C systems are concerned, here is a glimpse at what some of the other leaders are now doing:

—As *Dyna-Soar* vehicle prime, Boeing's chief concern has been the specification and integration of guidance and control into the space system. Current efforts are toward integration between primary and radio backup boost guidance, development of a satisfactory energy-management scheme to accomplish re-entry, and the development of glider flight control and secondary guidance systems. Boeing also is making an intensive study of space vehicle attitude control and rendezvous.

—Raytheon is pushing development of injection and orbital guidance and navigation techniques, using inertial platforms with star trackers and horizon scanners.

—Martin, among its many programs, is waging a development battle against excess size, weight, and cost of complex G&C systems. Also, it is attempting new approaches for stability and control by employing new self-adaptive techniques.

—RCA, also attempting to lessen excess weight and power in manned space vehicles, is employing micromodule fabrication techniques for hyperenvironment computers. It has another program to study the designs for various non-rotating, expandable guidance computer memories.

—Douglas is performing comprehensive studies of the whole control problem. Research is being performed in the analysis of a new adaptive control system employing a supervisory controller which adjusts system gain as a function of control surface effectiveness. This system, says Douglas, is unique in that it eliminates the requirement for air data measurements and calculations. In very-high-performance systems, where stagnation temperatures in excess of 1500°F may be encountered, serious material problems can be by-passed if air data probes are eliminated, the company said.

Methods of controlling large flexible missiles by ignoring elastic dynamic effects (by heavy filtering) and substituting computed high-frequency response also are being studied. These will provide a means of attacking the control problem of an aerodynamically unstable airframe in a dynamic wind shear environment, where high control gains are required. Other special control problems being studied include control of disturbing torques from atmospheric, solar, micrometeorite, gravitational, magnetic, and internal movement effects of manned vehicles operating in cislunar and interplanetary space.

—Nortronics is continuing its development of highly advanced stellar-inertial guidance systems. One, the A-5 astronertial navigation system, reportedly is 0.1 the size and 0.05 the weight of its predecessor in *Snark*. The system is a stellar-corrected, velocity-damped inertial package capable of accepting relatively poor initial condition data and yet provide maximum accuracy, according to Nortronics.

Another, the A-11, will be further minified. Now two years in development, it will be an all-attitude four-gimbal inertial system having, the company says, "the highest order of perfection yet achieved." ⁂

Auxiliary Power

(Continued from page 75)

to gain more power per unit cell—that is, by concentrating more solar power on each cell. This means that solar cells would be working in higher power ranges than they are now.

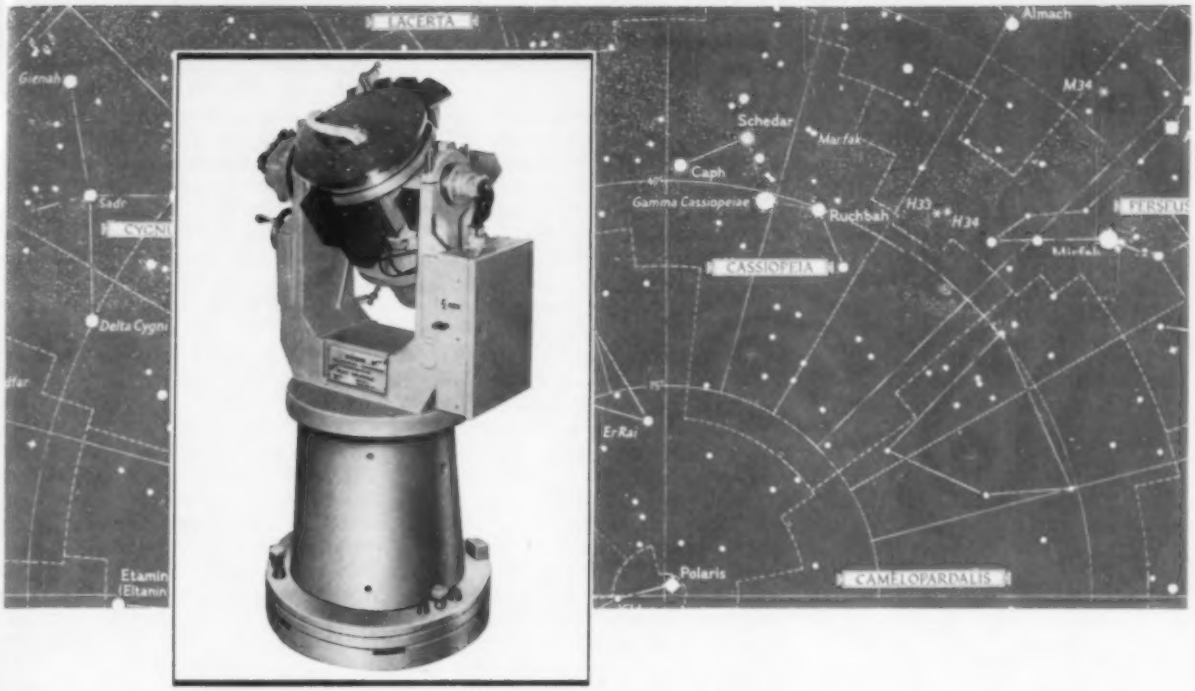
For this purpose, mirrors might be used to concentrate the sun's energy on a large solar-cell panel. Care must be taken to avoid overheating the cells and thereby loosing them.

A program is currently being initiated at Jet Propulsion Laboratory to look into this approach. JPL is also encouraging a modular solution to the problem, so that banks of solar cells can be added or subtracted according to the power required.

The Air Force is also known to be letting contracts on the solar-cell problem. Major companies working on the solution are Electro-Optical Systems and Boeing.

• **Thermal energy storage**—There is obvious interest in finding a way to store thermal energy in a compact unit which will operate a heat engine continuously when the spacecraft is passing in the shadow of a celestial body. One promising way is to store energy as the heat of fusion of a material whose melting point is higher than the heat input temperature to the heat engine. When the material entered the shade it would freeze, thereby releasing its heat of fusion to operate the engine at a constant output. Accordingly, a high value for the heat of fusion is desired.

Cooley points out that lithium hydride is good for heat engines operating below its melting point of 682°C. Soldium fluoride may be considered for use with boiling-liquid metal cycles



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(such as rubidium or potassium) or Brayton gas-turbine cycles at temperatures up to 992°C.

The beryllium-silicon eutectic appears suitable for cycle temperatures up to 1089°C. Molten beryllium, and particularly silicon, would be desirable for use with thermionic converters having cathode temperatures below 1350°C and 1420°C, respectively.

• **Solar-mechanical systems**—Three types of solar-mechanical power systems are now being developed—a 3-kw-output mercury-vapor turbine system, a 3.8-kw Sterling engine system, and a 15-kw rubidium-vapor turbine system.

The 3-kw system is being developed under NASA contract by the TAPCO Group of Thompson Ramo Wooldridge. Called "Sunflower," the system consists of a foldable petal-type solar collector that will open to a diameter of about 32 ft. The sun's rays will boil liquid mercury which will drive a turbogenerator to produce electric power. The thermal energy storage unit will permit continuous operation, even when the craft is in the earth's shadow.

Sunflower is being designed for possible use in spacecraft launched by *Centaur* and *Saturn* vehicles.

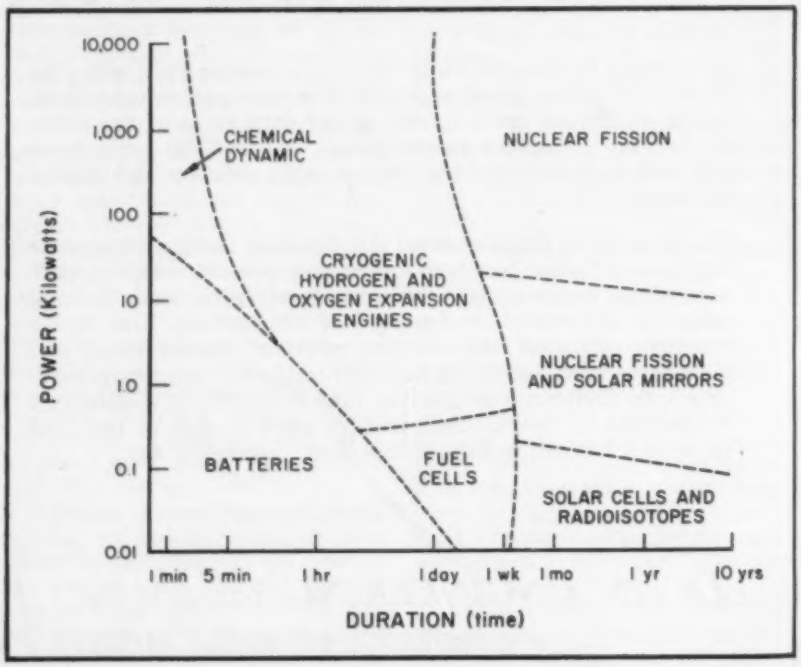
The Sterling engine is being developed for the Air Force by the Allison Div. of General Motors. Its high thermal efficiency—over 30% as compared to 11% for the Sunflower mercury Rankine cycle—makes it quite attractive because of the reduced size and weight of the collector and thermal storage system.

Nevertheless, the Sterling engine's disadvantage is that the low temperature of the cooling water (150°F to 250°F) requires a large-area radiator, not easily packaged into a spacecraft.

The 15-kw rubidium-vapor system is being developed for the Air Force by the Sundstrand Turbo Div. Although the high turbine-inlet temperature of 1750°F, with a radiator temperature of 675°F, will potentially yield a lightweight system (819 lb), there are still serious material problems to be solved involving a thermal storage unit and a lightweight solar collector.

• **Solar-thermoelectric systems**—Thermoelectric materals have been getting much attention from the Navy because of their possible use in static cooling systems for nuclear submarines. In addition, modular cooling of electronics through the thermoelectric effect is far more inviting than through mechanical systems (M/R, October 31, 1960, p. 22).

Currently, there are two feasibility contracts on solar-thermoelectric systems under way at Systems Command, Wright-Patterson AFB. The first, which involves a flat-plate solar collector, is held by General Atomic Div. of General Dynamics; and the second, involving a small parabolic collector, is held by Hamilton Standard. The major disadvantage of solar-thermoelectric systems is the large area of solar collector



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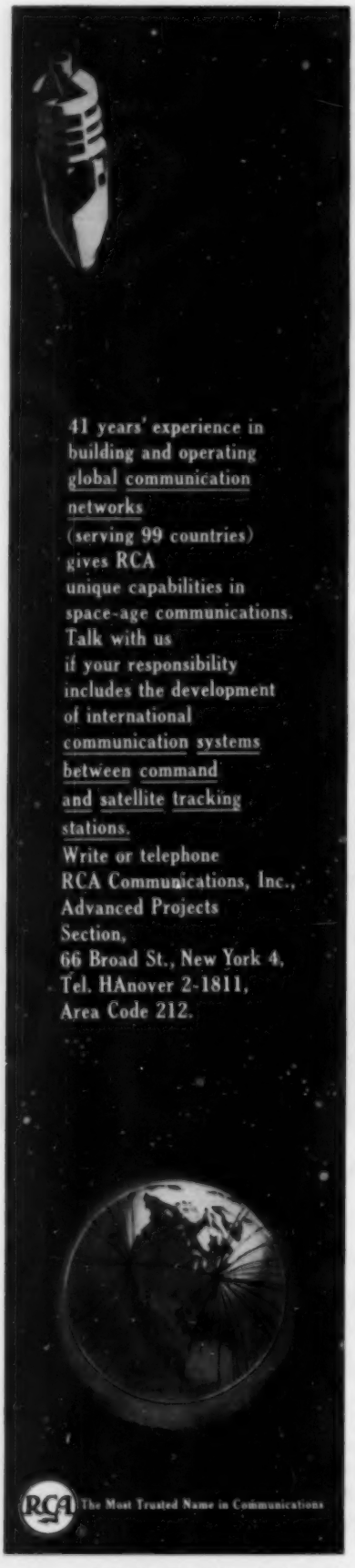

and radiator required per unit of electrical output; this is the result of the limited efficiency of presently available thermoelectric materials.

• **Solar-thermionic systems** — The Missile & Space Vehicle Department of General Electric has a Systems Command contract for a 500-watt solar-thermionic electric power system. A feasibility demonstration of the unit will shortly take place at Phoenix, Ariz. Called the "STEPS" system—an acronym for Solar Thermionic Electrical Power Supply—it uses a parabolic collector to focus the sun on a spherical array of thermionic converters.

JPL is in the process of letting a contract for a solar-thermionic module capable of putting out 130 watts.

• **Nuclear power systems**—NASA does not plan to use any nuclear APU's for manned space flight in the present decade because of shielding problems, lack of redundancy in many instances, and because of the relatively short duration of the planned flights. Nuclear APU's do not show to large competitive advantage until flight times begin exceeding one month.

The SNAP units are the most well known nuclear APU's (M/R, August 22, 1960, p. 39). SNAP-3, a thermionic-isotope device developed by the Martin Co., produces six watts and weighs just under a pound. It can be used for unmanned deep-space probes and soft lunar landings.

SNAP 2, 8 and 10 are the three space nuclear - reactor electric - power units that the Atomic Energy Commission is currently developing for NASA and the Air Force through the Atomics International Div. of North American Aviation.

The SNAP-2 system is designed to generate 3 kw of useful electrical power continuously for one year. A flight-capable version of this system will be delivered to the Air Force in 1964.

The SNAP-8 device is a larger version of SNAP-2. It will produce 30 kw with one power conversion unit and 60 kw with two power conversion units coupled to the same reactor. NASA has announced that if the system works it will be used for such purposes as long-life communications and electric propulsion devices. The first SNAP-8 experimental reactor will go critical early next year: AEC expects the flight tests will be conducted sometime in 1965.

The AEC describes SNAP-10A as a system that will demonstrate the capability of the SNAP reactor powering a thermoelectric converter located in the vehicle's skin. The reactor is about the same as in SNAP-2, but the converter in the system will put out 500 watts. AEC expects the flight-testing of SNAP-10A to take place sometime in 1963. ⌗

Spacecraft

(Continued from page 43)

The weight penalty involved in *Dyna-Soar's* wings was a major factor in the recent decision to switch from *Titan I* to *Titan II* as a booster. *Titan I* is able to lift 3000 lbs. into a 300-mile orbit, while *Titan II* will have a capacity of 8000 lbs. But the Eisenhower Administration starved development of the glider so that it wouldn't be ready until *Titan II* was ready, anyway.

• **Timetable**—Even with the time lost, *Dyna-Soar I's* first flight is still expected to be one to two years ahead of the three-man *Apollo*—assuming *Apollo* becomes a program. With *Titan I*, *Dyna-Soar* flight tests were to begin in early 1963. The exact timing of both *Dyna-Soar* and *Apollo* depends on funding decisions to be made by the Kennedy Administration and Congress.

Dr. Wernher von Braun, director of NASA's Marshall Space Flight Center, has said that the *Saturn C-1* will be ready for manned flight by the end of 1964 or early 1965. If *Apollo* and *Dyna-Soar* are pushed as fast, it may be possible to fly them on early earth-orbiting missions during that period. *Dyna-Soar's* suborbital flight could come in late 1963 or early 1964 if *Titan II* is ready by then for manned flight.

Saturn C-1 will have orbital payload capacity of 19,000 to 20,000 lbs., which will provide plenty of margin for the orbiting *Dyna-Soar*. For orbital *Apollo* flights, the *Saturn C-1* will be able to lift a three-segment spacecraft.

The basic *Apollo* unit will be the command center, weighing about 10,000 lbs. For the orbital mission, a 2500-lb. propulsion module will provide attitude control, some orbital maneuverability for rendezvous experiments, and retropropulsion capability to reduce the velocity by 500 fps for return from orbit.

A third segment will be the so-called mission module weighing 7500 lbs., which will provide a second room for living space and to conduct orbital experiments. The mission module will be separated prior to re-entry and will remain in orbit.

Although NASA has decided it cannot afford the weight penalty involved in giving *Apollo* a glider shape, with a relatively high lift/drag ratio, the spacecraft will have aerodynamic control surfaces and thus will not be a purely ballistic body. *Apollo's* lift/drag ratio will be between 0.4 and 0.7—compared with 2 or more for a *Dyna-Soar* type glider.

• **Apollo's shape?**—The modest amount of lift plus control surfaces will allow the *Apollo* crew to vary their landing point by upwards of 1000 miles

longitudinally and by a few hundred miles laterally. However, the final descent will be made by parachute, just as with the *Mercury* capsule.

By comparison, a craft with lift/drag ratio of 2 can vary its longitudinal range up to 9000 miles from orbital velocity. Its lateral range can be varied up to 2500 miles.

The *Mercury* capsule itself has a lift/drag ratio of 0.4. However, the lift is not utilized because there is insufficient heat protection on the afterbody. With high-temperature materials, the *Mercury* capsule shape becomes one candidate for *Apollo*.

The accompanying illustration shows five basic shapes that were considered in the *Apollo* studies recently completed by NASA contractors. The two at the left—the glider and the circular lenticular body—have high lift/drag ratios and high resulting weight penalties that have caused their rejection. The other three are still in the running. The *Mercury* shape is represented at the lower right.

The second version of *Apollo*, designed for the circumlunar mission, will have only two modules, the command center and an expanded propulsion module. *Saturn C-2* is to have the capacity of launching 15,000 lbs. to escape velocity. The basic command center will remain at 10,000 lbs. but the propulsion module will rise to 5000 lbs.

The corridor for re-entry from the lunar flight will depend on the lift/drag ratio. A purely ballistic flight would have a re-entry corridor 8 miles wide. With a lift/drag ratio of 0.4, the width rises to about 40 miles. However, the curve flattens and the additional corridor width attained with an L/D ratio of 0.7 rises only to 45-48 miles.

Many elements of the basic *Apollo* command center would be used for the later lunar landings. Plans are still based on total weight of about 10,000 lbs., although some obvious structural additions would be required to set down on the lunar surface. The major difference will be in the propulsion module. To provide retropropulsion for soft lunar landings and liftoff for the return to earth trajectory, about 200,000 lbs. altogether must be boosted to escape velocity.

There is some possibility that the three-module design might be followed for the circumlunar vehicle. If the weights can be shaved down enough, a separable mission module might be included, so that only a relatively light re-entry vehicle might come in from the circumlunar flight. However, that decision will not be made in the design of the first *Apollo* for the orbital mission.

• **Apollo modules**—Of the 10,000 lbs. weight in the *Apollo* command

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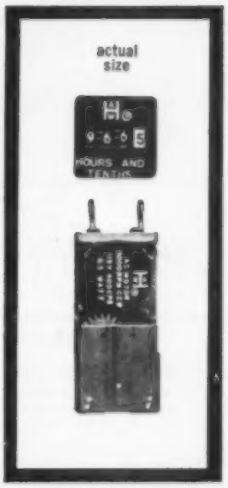

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Comparison of Apollo and Dyna-Soar Spacecraft

	Apollo Orbital	Apollo Circumlunar	Dyna-Soar I Suborbital	Dyna-Soar II Orbital
Crew	3	3	1	1
Weight	20,000 lbs. in orbit 12,500 lbs. re-entry	15,000 lbs.	About 10,000 lbs.	About 10,000 lbs.
Booster	Saturn C-1	Saturn C-2	Titan II	Saturn C-1—Class.
Shape	Lifting body	Lifting body	Glider	Glider
Lift/Drag Ratio	.4 to .7	.4 to .7	2 or more	2 or more
Landing Method	Parachute	Parachute	Like jet aircraft	Like jet aircraft
Aerodynamic Control	Limited	Limited	Complete	Complete
First Flight Scheduled	1965-66	1967-68	1963-64	1964-65

center, NASA figures that structure, heat protection and related systems will weight about 6000 lbs., life support and occupants will weigh 2500 lbs. and the 400 kilowatt-hour power supply will weigh 1500 lbs.

The command center will be a cylindrical segment 10 to 15 ft. in diameter and 6 to 8 ft. long. The mission module would be slightly smaller, with volume equivalent to a 7-8 ft. cube.

The major difference between the overall design of *Apollo* and the *Mercury* capsule would be on the afterbody. *Mercury* has protection against re-entry heating only on the blunt face. Its afterbody exterior consists of shingles made from a nickel-cobalt alloy capable of withstanding tempeartures in the 2000°F range. The *Apollo* afterbody probably will have ablative materials. However, there is a possibility of exotic metals.

The propulsion module will have the capacity to change the velocity by 1000 to 2000 fps for rendezvous experiments in the orbital mission. For the maneuvers required to steer the spacecraft around the moon, about twice that capacity will be necessary.

The largest single problem in the design of the *Apollo* spacecraft is re-entry. The first phase of the work will be a series of basic investigations of materials and shapes at Mach 40—over a period of several months, and possibly up to a year or more. Then several likely shapes will be tested in vertical flights, first with *Scout* vehicles and later with *Atlas-Agena B*.

• **Must head for port**—Navigation is complicated by the constant necessity of "escape." Even when the mission is well on the way to the moon, there is a requirement of capacity to turn around and scoot for home. For there are no plans to carry heavy radiation shielding. *Apollo* will depend on solar "weather forecasting" and schedule its flights when no flares are expected.

The clouds of protons and electrons spewed by solar flares are no hazard to the early *Apollo* orbital flights, which will be below the lower edge of the Van Allen radiation belts. The earth's magnetic field will prevent the proton clouds from penetrating that close.

For the circumlunar flights, NASA plans to rely heavily on predictions based on a technique developed by Kinsey Anderson of the State University of Iowa. The Anderson technique, by studying sunspot penumbra, makes it possible to predict with fairly high

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certainty that a solar flare will not occur in the next few days. Others believe similar predictions can be made on the basis of sudden variations in the earth's magnetic field.

So far, no one has claimed the ability to predict for a period of seven days, the length of a circumlunar flight. Thus there remains the possibility of a warning of solar activity after the flight is under way.

Industry calculations indicate that with 6000 fps retropropulsion capability it might be possible to return to earth within 40 to 50 hours when halfway to the moon. However, the craft is not likely to be carrying more than about 4000 fps propulsion—enough for return in about three days.

The best solution would be a close watch on the solar weather both before and during the flight, so that the on-board propulsion might be used for the reversing maneuver if signs appear that the sun will be acting up soon.

For radiation shielding, the plan is to make maximum use of equipment and supplies that must be carried anyway. For example, the water supply will be carried in flat tanks that will cover much of the interior. A bit of shielding material may be spotted about to fill holes left by the on-board equipment.

The Air Force program calls for prototype *Dyna-Soar* re-entry tests launched by *Blue Scout* rocket vehicles next year. The full-scale glider will be tested in airdrop flights from a B-52, similar to the *X-15* launching technique.

The *Dyna-Soar* re-entry problem is quite different from that of a drag vehicle like *Mercury* or *Apollo*, which re-enter in five to eight min. and encounter g loadings up to 10 or more. The *Dyna-Soar* takes 30 min. to an hour or more for re-entry and the g loading is much lower. On the leading surfaces and edges, the heat-transfer rate is less than the drag vehicle, but because of the large surface involved, the total amount of heat is greater.

Cooling methods under consideration include radiation, ablation, fluid injection, heat sink, active fluid and magnetohydrodynamic. Considerable test data is needed before the final decision is made on a method or combination of methods.

The best guess on the material choice probably is graphite for the hottest portion, backed up by a somewhat stronger ceramic material. Behind the graphite-ceramic combination would be a high-temperature metal with even greater strength for the basic structure. If such a combination does not get rid of the heat fast enough by radiation, some sort of circulating fluid method will probably be adopted.

(Continued on page 113)

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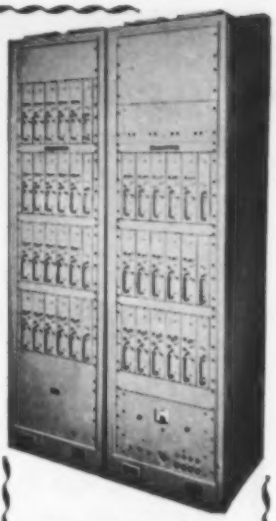

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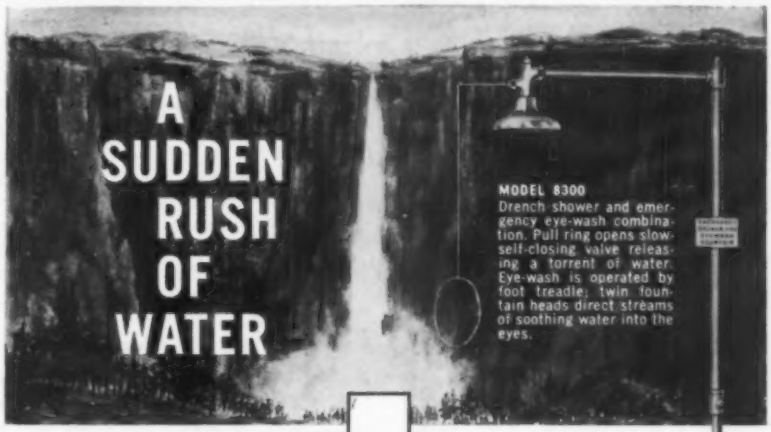
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soviet affairs

By Dr. ALBERT PARRY

Who built Gagarin's rocket?

This question must have been asked of the Soviet cosmonaut, by foreign journalists at least. For in a recent article, "The World in One Hundred Minutes," in *Izvestia* the Major declared: "The world does not as yet know the names of those who built the cosmic rocket, and the time to know has not as yet come."

Yuri Gagarin thus echoes Nikita Khrushchev's famous dictum of July 9, 1958, in a speech to factory workers at Bitterfield, East Germany. The Soviet boss said then that Soviet "scientists and engineers working in atomic and rocket technology," although well paid and otherwise privileged, "have to suffer somewhat in only one respect: for the outside world they are, for the time being, anonymous."

On that occasion Khrushchev went on: "We highly value these people, we prize them and protect their safety from hostile agents who might be sent to destroy these outstanding people, our valuable cadres. But now, in view of the safety of the country and of the lives of those scientists, engineers, technicians, and other specialists, we may not as yet make public their names and their photographs."

Nearly three years

have passed, but the policy still stands. Compare this secrecy with the many proud advertisements rushed into American print by companies describing in photos and words the contributions they made to Commander Shepard Jr.'s rocket and capsule. Add to this the numerous interviews, both published and televised, with the American scientists and engineers responsible for these contributions, and you have one more illustration of the contrast between the open society of the West and the closed world of the Communist East.

What about foreign observers?

I asked this question on the morning of April 12, a few hours after the news flash about Gagarin and his *Vostok*. It was addressed to Professor Leonid Sedov, the Soviet astrophysicist, as both of us appeared on Dave Garroway's NBC television program "Today." I pressed: Will the Soviets allow foreign observers to be present at the next landing of a Russian cosmonaut? My implication was that secrecy was hurting the Soviets, that because of it not all the people in the world would believe their rocketry claims.

Professor Sedov replied that he could not promise invitations to foreign observers for the very next Soviet cosmonautic launching or return, but that in the near future such invitations might be possible—provided there is a relaxation of general international tensions.

The Moon, Mars, and Venus

are Major Gagarin's future destinations. This was revealed in his article, "The Time of Stars" featured in *Krasnaya Zvezda*, the armed forces daily, on May 1. He stated that his orbiting flight of April 12 "does not end" his career. "I want to do some real flying," he emphasized, and wrote of his hopes for rocket trips to the Moon, Mars, and Venus.

But human journeys that far

are ruled out, for the near future, by Soviet scientists. One week after Gagarin's flight, *Komsomolskaya Pravda* published an interview with Academician Vasily V. Parin, in which that foremost Soviet space-medicine expert maintained that for the time at hand "biologists won't give the cosmonaut their permission" to fly to the Moon. Such longer routes have to be investigated thoroughly "first by automatic instruments, later by animals, and only then a man would fly."

But the door to such exploits is open. Professor Parin says: "The main job is done. Others will follow Gagarin. In time, men will walk in that eternal lunar dust, will fly from planet to planet, will learn to live in Cosmos for as long periods of time as they would wish—will, finally, penetrate to other stars, too."

ARS meeting told . . .

Space Has Small Military Value—Now

by Reed Bundy

PRINCETON, N.J.—The nation's space program so far includes nothing of "important military value" other than reconnaissance satellites, Courtland D. Perkins, former Assistant Secretary of the Air Force for Research and Development, said here recently.

"Reconnaissance is a real strategic role—though peripheral—and it has DX-1 priority," Perkins said. "But so far nothing else of important military value has been found in the space program."

The former AF official, now chairman of Princeton University's Department of Engineering, moderated a symposium on "National Perspectives in Space," held by the Princeton Section of the American Rocket Society.

Other speakers at the off-the-cuff session were Dr. E. W. Engstrom, senior executive vice president of Radio Corporation of America; Dr. Donald F. Hornig, head of Princeton's Chemistry Department and a member of the President's Scientific Advisory Committee; Dr. Klaus E. Knorr, economics professor and former consultant to the Rand Corp.; and Dr. Robert Jastrow, chief of the Theoretical Division, National Aeronautics and Space Administration.

Perkins, who served as Chief Scientist of the Air Force in 1956-57 before becoming assistant secretary, said that he thought that "under the circumstances it was a pretty good idea" in 1958 to give NASA responsibility for space and leave the military with strictly military roles.

"It may have delayed space program progress—but it is debatable whether putting it under the military would have gotten it done any quicker."

"In the military," he explained, "we were looking at the space program for things of great military value. We were able to identify very few military applications that couldn't be better served by other means."

"In my opinion," Perkins said, "nobody has ever been able to show that space-dropping (of bombs from satellites) could be done—or, if it could be, that it could be done as effectively as bombs can be delivered by ICBM's, *Polaris* and *Skybolt*."

As to another suggested military use of space—for platforms from which to launch antimissile-missiles at enemy ICBM's on takeoff—Perkins said "we would love to have a way to do it from space, but nobody has found a way."

• **If opponent knows . . .**—Knorr argued that even reconnaissance satellites would not be of "crucial" military value in spotting war preparations although they might be useful once the conflict was under way.

Conceding that his special knowl-

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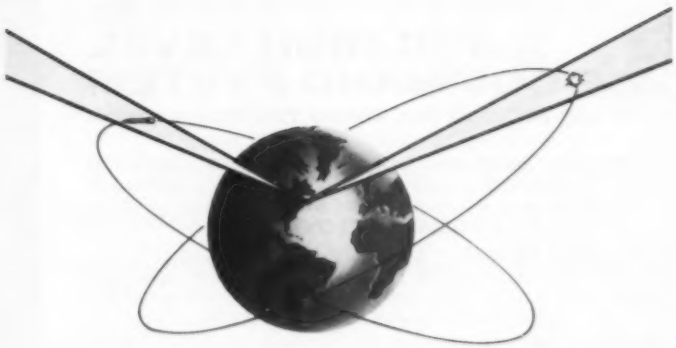

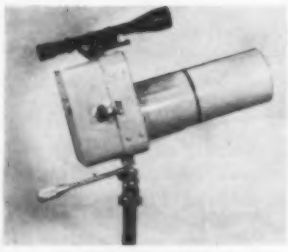

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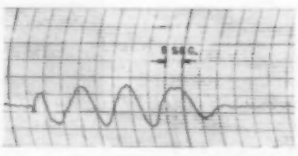

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edge was of overall strategy, rather than space, Knorr discounted the effectiveness of satellites for target intelligence.

"It works well if your opponent does new and different things which can be spotted in satellite photographs," he said. "But if he knows you have such a system, he won't move out of advanced bases before attacking, or do the other things which would be tip-offs. Besides, the Soviets have shifted to mobile systems of missile transport and launching—as we are doing—and the vehicles involved can easily be made to look like peaceful vehicles and equipment."

New knowledge acquired through the space effort in fields such as communications and weather should "upgrade military performance," Knorr said, "but whether this improvement will be any more than marginal is still in doubt. We might find ourselves upgrading performance through space work at the expense of other ways."

Weapon systems in space do not yet "make sense," he said. "We must look at such proposals thoroughly because there may be more in them than we think. But this is R&D only."

• **"Payoffs" lacking**—Perkins said that reconnaissance satellites are the "only military production payoff" in the space field, although various other low-orbit satellites are doing work in such areas as communications and geodesy.

"The *Saint* and *Dyna-Soar* programs will yield hardware contracts eventually, and the military payoff of *Dyna-Soar* is obvious," he said. "Project *Defender* and space bombardment proposals have great potential."

But he observed that "there is no production money for space anywhere in the Fiscal Year 1962 defense budget." He said the Air Force has been given about $1 billion for space work, but it is all R&D money.

• **Industry's obligation**—Dr. Engstrom said there is "some" monetary profit for industry in military and scientific space work, apart from hardware, and that eventually there are profitable applications in the civilian market.

Above and beyond this, he said, industry "has an obligation" to make contributions.

Looking toward the future, the RCA executive said the "demand on existing communication facilities is so heavy and growing so rapidly that, even allowing for the growth of submarine cable, we will need the new space communications facilities by the end of this decade."

He said the questions of who should own, operate and manage the communications satellite system will have to be solved through government-industry cooperation.

• **Space vs. cosmetics**—Dr. Jastrow predicted that operational weather and communications satellite systems will be in orbit within a few years.

"As well as I can tell," Jastrow said, "the economic benefits of the space program will be measured in billions of dollars annually. And our investment in space is only now approaching what American women spend on cosmetics: the ladies invest $2 billion a year on cosmetics, NASA is now inching toward $2 billion a year."

Jastrow said the biggest problem NASA faces in space exploration is the booster gap.

"Everybody has been talking about the gap, but nobody has done anything. We must address ourselves to the question: exactly what *is* our booster requirement?"

Asked whether there were plans to advance the U.S. deadline for a lunar landing, the NASA official said he believed the Administration was "considering acceleration of the *Apollo* program—with more funding."

"More funds would be needed," he said, "but where would they come from? It's hard to get more by raising taxes."

Engstrom said he doubted that the public would be unwilling to sacrifice for the space effort. "I believe that if the people were asked, the space program would get more money than it would know what to do with." ⌘

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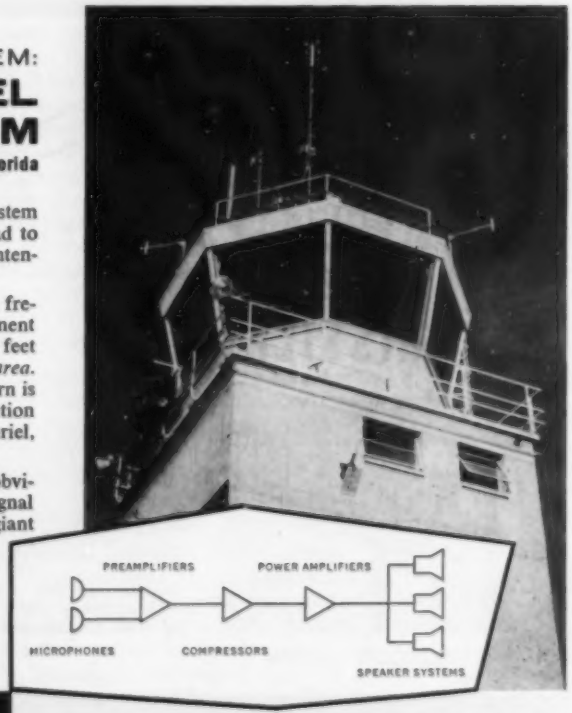

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(Continued from page 109)

The glider's surfaces must deal with temperatures varying from 2000° to 4000° F on re-entry. A mockup of the glider is to completed by fall.

Boeing says *Dyna-Soar* will have the most exhaustive wind-tunnel program in the history of flight—about three times the total time spent gathering data for the *X-15* and about twice that required for the B-52.

Many combinations of glider and booster must be tested at various speeds —the glider atop the complete missile, the glider and second stage after separation and the glider in free flight. Tunnels used will generate subsonic and transonic speeds, from low speeds to Mach 1.4; supersonic speeds, from Mach 1.5 to 5.5; low hypersonic speeds, from Mach 6 to 10; and high hypersonic speeds, from Mach 12 to 25.

• **Lunar base confusion**—All but lost in the spacecraft debate are considerations for providing vehicles with which to set up a lunar base. Planning in this area is rather nebulous and almost entirely dependent upon progress in big booster development.

Whether a larger version of *Apollo* could undertake this mission is still questionable at this date—particularly if it developed that there was an urgent need for a military base on the moon along about 1967 when the Russians claim they will be there.

Saturn C-2 is generally thought to be the best bet for putting sizable payloads on the moon. But it won't be ready until 1966 or 1967. This is the factor behind military and industry urgings to proceed immediately with a large solid-fueled rocket program aimed at obtaining a booster vehicle by 1965 that could carry out lunar missions.

The Air Force, which has been pushing limited development of big solids, has not made public any designs for spacecraft to go aboard them. Whether it has or will arrive at a ballistic-type shape for manned or unmanned craft is not known.

However, critics of *Apollo* feel that this approach has another major drawback besides its high entry speed:

Apollo, because of its parachute descent system, must land in the ocean. This means that every time it goes on a mission a considerable portion of the U.S. Navy will be tied up in the recovery operation. This would be an expensive and not very convenient expedient, especially if it becomes necessary to build up a rather large and well-populated lunar base involving frequent flights.

An orbital return via a winged craft would seem preferable. ¤

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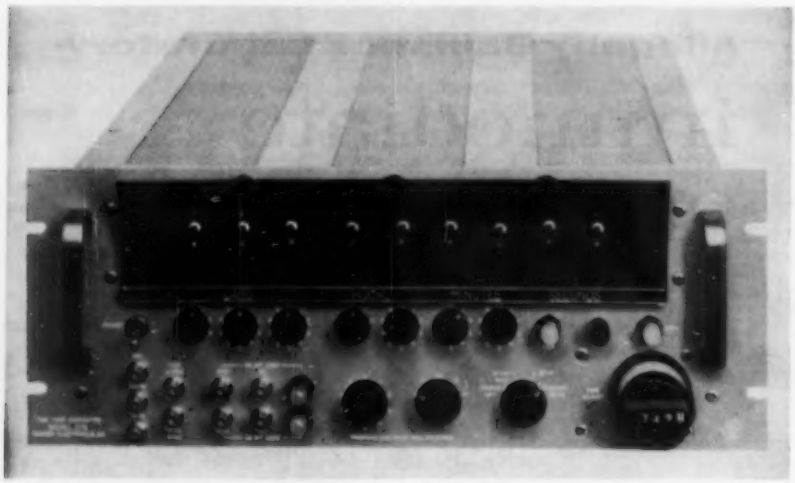

Time Code Generator

The Model 275, a time code generator producing a precise time reference for data acquisition systems, is being marketed by Hermes Electronics Co., a division of Itek Corp. The Model 275 is available in three versions, Types A, B, and C. The difference between types is in the format of the time-code outputs. Type B meets the specifications of the Inter-Range Instrumentation Group (IRIG) Recommendation No. 104-60, formats B and C. This all-solid-state instrument generates seven time-code outputs. The first six, in serial form, are for high- and low-speed analog magnetic tape recorders, oscillographs or data-recording cameras. The seventh is a 42-bit parallel output used for digital acquisition systems or on line computer applications.

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Heater-cathode subminiature tubes with warm-up time of only five seconds are available from Raytheon Co., Industrial Components Division. The QV112 is a medium-mu triode and the QV113 is a sharp-cutoff pentode. Contained in T-3 envelopes, both tubes operate efficiently in the VHF region and operate at bulb temperatures to 220°C.

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A display for annunciators that provides up to sixty messages is available from Industrial Electronic Engineers, Inc.

Called the Series 90000H Display, it is designed for those annunciator applications where simultaneous data is required in a fast, easy-to-read method. It has a capacity of 60 messages which may be displayed individually or in combination, or a 50-message capacity with red or green color backgrounds available.

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The Precision Clinometer is invaluable in setting inclinable tables for jig borers, and angular work on grinding and lapping machines; for checking angular faces and locations on jigs, fixtures and gages.

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Two powder injection holes make it possible to spray 20% more powder than was previously possible with the SG-1 arc plasma spray gun available from Plasmadyne. Development of the dual injection holes enables more precise control of powder velocity in spraying applications. Coatings now can be tailormade to suit coefficients of expansion of various substrates to meet requirements of different chemical or thermal requirements. Two different powders can be fed into the arc.

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Sweep Generators

A series of RF sweep and signal generators capable of providing up to 4 watts of power are available from Telonic Industries, Inc. Six models,

designated PD-1 through PD-6 are included in the line of test instruments that cover the RF range from 5 to 1000 mc. A switch arrangement on the instrument enables the user to select from four different modes of operation including swept RF, swept RF with 1000 cps square wave modulation, unmodulated CW and CW with 1000 cps square wave modulation.

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Impedance Bridge

A Model 710A Universal Impedance Bridge for measuring the capacitance and dissipation factor of capacitors, the induction and storage factor of induc-

tors, and the AC-DC resistance of resistors is available from John Fluke Mfg. Co., Inc. The unit has an accuracy of ±(0.1%+1 dial division) and a capacitance of 0 to 1200 microfarads in 7 ranges.

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Commutator

The Electronics Division of Arnoux Corp. is producing a 30-channel unit, designed for airborne general-purpose telemetry. Output levels are maintained within ±0.5% of full scale over entire temperature input-power voltage, duty cycle, and rate ranges with any combination on input signal levels.

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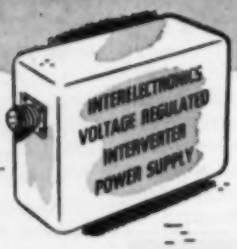

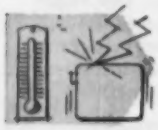

Interelectronics all-silicon thyratron-like gating elements and cubic-grain toroidal magnetic components convert DC to any desired number of AC or DC outputs from 1 to 10,000 watts.

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Complies with MIL specs. for shock (100G 11 misc.), acceleration (100G 15 min.), vibration (100G 5 to 5,000 cps.), temperature (to 150 degrees C), RF noise (1-26600).

AC single and polyphase units supply sine waveform output (to 2% harmonics), will deliver up to ten times rated line current into a short circuit or actuate MIL type magnetic circuit breakers or fuses, will start gyros and motors with starting current surges up to ten times normal operating line current.

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amps. The hermetically sealed units are available for immediate delivery in a choice of three configurations: (1) axial type with molded, insulated body, (2) axial type with molded, insulated body with lugs on both ends or (3) for direct replacement of the stud base types.

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Circuit Protector

An electronic circuitry protector, a sealed, direct current operated, non-polarized, electromagnetic fault or overload current limiting device with self-resetting capabilities, is available from North Electric Co. Speed of operation of the CP-226 depends upon overload magnitude, within 1 to 10 milliseconds of fault occurrence. It trips within ±10% of specified current.

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Shaft Encoders

A line of 20 and 30 analog/digital, detented shaft encoders is available from Guidance Controls Corp. Known as the DADC Series, this line was developed for those read-out applications where it is necessary to translate a rotary shaft position to a coded digital output (binary) for tape storage or direct insertion into digital computers.

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Tunnel Diode Amplifiers

A complete line of low-noise, narrow-band tunnel diode amplifiers, NTA Series, is available from Micro State Electronics Corp. NTA amplifiers are self-contained units which may be added directly to the front end of existing radar, troposcatter, ground and satellite communication systems. The units are available with 0-10% bandwidths over a range of 375-1400 mc.

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Modular Units

Modular plug and receptacle units capable of multiple circuit connections from 3 to 60 circuits are available from Molex Products Co. Additional polarization is possible by inter-mixing male

and female terminals in plugs and receptacles. The round, pin-type terminals automatically crimped to wires eliminate soldering and permit fast, simple assembly.

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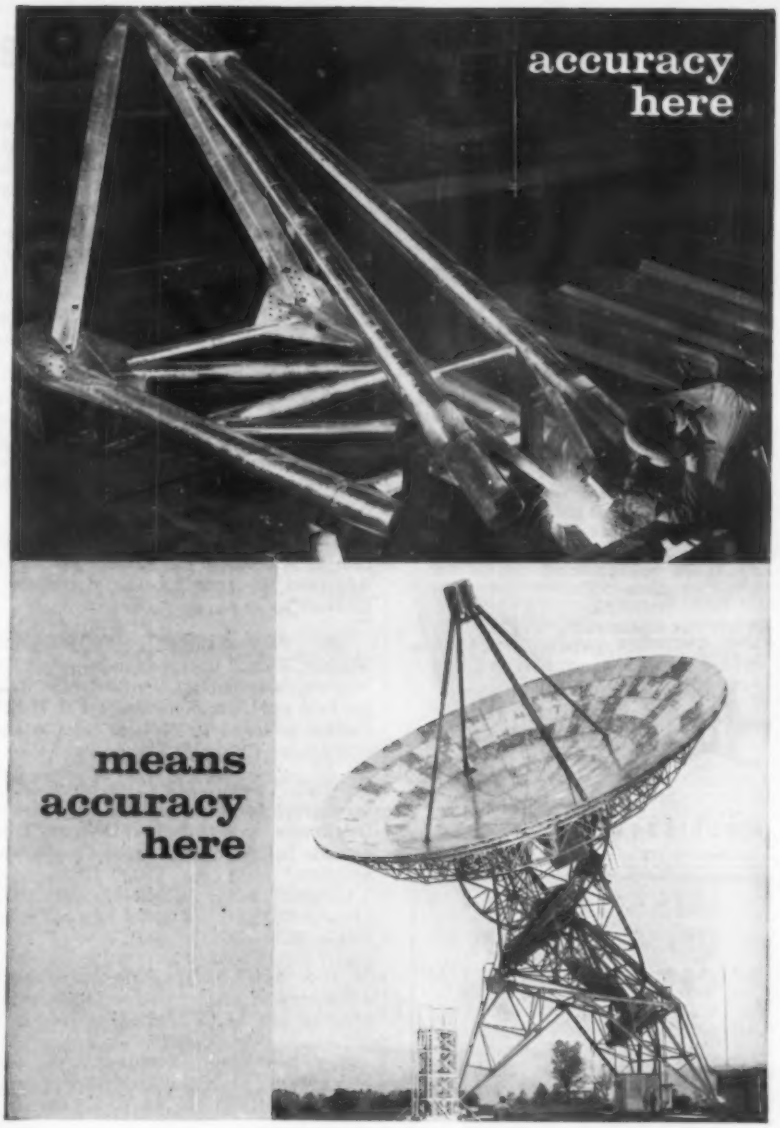

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names in the news

Dr. H. Guyford Stever: Professor of Aeronautics and Astronautics at Massachusetts Institute of Technology, elected to the Board of Directors at Trans-Sonics Inc., Lexington, Mass. Dr. Stever is a member of the Defense Science Board and chairman of the NASA Research Advisory Committee on Missiles and Space Vehicle Aerodynamics. He is also a member of the Scientific Advisory Committee to the Committee on Science and Astronautics of the U.S. House of Representatives.

James W. Dunham: Named president of Space Recovery Systems, Inc., El Segundo, Calif., a division of Itek Corp. Prior to joining SRS, Dunham was research director of Booz-Allen Applied Research, Inc.

Dr. Carl L. Kober: Former vice president of Avco Corp., appointed director of Advanced Programs for The Martin Co.'s Denver Division.

Dr. Paul Kruger: Joins Hazleton-Nuclear Science Corp., as manager of the Nuclear Projects Dept. Formerly Dr. Kruger held similar responsibilities with H-NS' Eastern affiliate, the Nuclear Science and Engineering Corp., Pittsburgh, Pa.

Wells Chapin: Appointed manager of marketing for communications, Avco's Electronics and Ordnance Division, Cincinnati. Before joining Avco, Chapin was associated with the Dage Division of Thompson Ramo Wooldridge, Michigan City, Ind., and General Electric's Electronics Division.

L. J. "Lew" Staehle: Promoted to assistant to the general manager of Lockheed's Missiles and Space Division. With Lockheed since 1954, Staehle will coordinate the activities of all organizations at the Van Nuys, Calif., plant for the division general management.

Dr. Frederick W. Lipps: Former research physicist at Aerolab Development Co., joins Electro-Optical Systems, Inc., as senior scientist in the Fluid Physics Division, Pasadena, Calif.

Lawrence G. Lutz: Named manager of the new West Coast plant of J. W. Fecker Division of the American Optical Co., Santa Monica, Calif. **William O. Hedge** named products manager.

Warren C. Hume: Promoted to president of the Data Processing Division, International Business Machines Corp., succeeding **Gilbert E. Jones,** who has been appointed assistant to the president.

Larry G. Hastings: Former information director for NASA's Goddard Space Flight Center, appointed director of public relations for Washington Technological Associates, Rockville, Md.

L. D. Brown: Named chief engineer for Aerotest Laboratories, Inc., Deer Park, L.I., N.Y., and will continue as chief engineer of the Advanced Propulsion Division.

Maj. Gen. William L. Rogers: Vice-commander of the Missile Test Center, Patrick AFB, Fla., named commander of the Arnold Engineering Development Center, Tullahoma, Tenn. **Colonel Harry J. Sands, Jr.,** has been named to replace Gen. Rogers at the AFMTC.

Richard G. Weber: Appointed regional planning manager and will form and manage the Washington Office of Cutler-Hammer's AIL Division. Before joining AIL, Weber was manager, systems planning, of General Electric Co., Bethesda, Md.

Louis H. Aricson: Vice president of Daystrom, Incorporated, named chief executive Officer of the Weston Instruments Division, Murray Hill, N.J. **Joseph F. Degen:** Former Weston general manager, assigned to the corporate staff post of assistant vice president, manufacturing.

Dr. James L. Wyatt: Named vice president for program development at the Armour Research Foundation of Illinois Institute of Technology.

Charles R. Covey: Appointed manager of manufacturing for Texas Research & Electronic Corp., Dallas. Formerly Covey was manufacturing superintendent, Semiconductor Division of Texas Instruments Incorporated.

H. E. Bauer: Former assistant chief project engineer on the *Skybolt* program at Douglas Aircraft Co., Santa Monica, Calif., named *Skybolt* program manager, succeeding **J. A. Gorgenson,** who has been assigned to the staff of the vice president-defense programs.

Philip S. Hanson: Named product development engineer at The Beryllium Corp., Reading, Pa. Previously Hanson was with Bridgeport Brass Co. and Monsanto Chemical Co.

Dr. John M. Brabant: Former staff member of the National Bureau of Standards, joins operations staff of The Bissett-Berman Corp., Santa Monica, Calif.

Donald W. Baisch: Appointed assistant to the vice president of Telecomputing Corp.'s Electronic Systems and Value Engineered Products Divisions. **John W. Rhyne, Jr.,** named chief electrochemist of TCC's Power Sources Division, Denver.

Dr. Donald C. Schiavone: Authority on design and development of rocket engines, named director of reliability on corporate engineering staff of The Martin Co., Baltimore. Previously, Dr. Schiavone was assistant chief engineer of the Rockets Division, Bell Aerosystems Co., and manager of propulsion system design for the Chrysler Corp.'s Missile Division.

Edgar O. Dixon: Named manager of the systems group at American Optical Co.'s Research Center, Southbridge, Mass., presently completing development of a target-detecting device for the advanced *Sidewinder* missile.

contracts

NASA

$3,250,000 — Radio Corporation of America, New York City, from Goddard Space Flight Center, for construction of the *Relay* communications satellite.

$1,276,000—Alpha Corp., Dallas, subsidiary of Collins Radio Co., from Goddard Space Flight Center, for equipment and electronic systems for tracking and receiving data relayed from satellites.

$264,771—Bendix Corp., Radio Div., Owings Mills, Md., from Flight Research Center, Edwards AFB, for operation and maintenance of two tracking stations within the *X-15* high range.

$94,800—Progressive Welder and Machine Co., Pontiac, Mich., from Marshall Space Flight Center, for a fifth *Saturn* assembly fixture.

$75,000—Martin Co., Baltimore, for Earth-Lunar Transport project study of launch vehicle systems for lunar exploration beyond the initial Project *Apollo* flight.

Menasco Manufacturing Co., Burbank, Calif., from **Douglas Aircraft Co.,** for titanium-alloy pressure vessels for *Saturn S-IV*.

ARPA

$81,708—Space Technology Laboratories, Los Angeles, from **General Dynamics/Astronautics,** for experimental modules to be attached to *ARENTS* (ARPA Environmental Test Satellite).

ARMY

$2,180,000—Fairchild Engine & Airplane Corp., Hagerstown, Md., additional funding for modification of two AN/USC-5 drone surveillance systems.

$716,954—Defense Electronic Div. of Radio Corporation of America, Moorestown, N.J., for installation of instrumentation tracking radar on Pacific Missile Range.

The Garrett Corp.'s AiResearch Manufacturing Division, Phoenix, Ariz., for small gas-turbine engine for the *Mauler* missile. No amount disclosed.

NAVY

$21,000,000—North American Aviation, Inc., Downey, Calif., from BuShips, for Ships Inertial Guidance Systems (SINS) for nine Lafayette-class *Polaris* submarines.

$6,970,000—Hughes Aircraft Co., Culver City, Calif., for combining *Polaris* inertial guidance platforms produced by another firm with Hughes-made guidance electronics systems and testing in the assembled units; **$2,400,000 from General Electric** for circuit boards for digital computers used in *Polaris* guidance units.

$1,001,108—Texas Instruments, Inc., from BuWeps, for AN/APS-88 radar systems.

$700,000—Sperry Microwave Electronics Co., Div. of Sperry Rand Corp., Clearwater, Fla., from BuWeps, for parametric amplifiers.

AIR FORCE

Westinghouse Electric Corp., Pittsburgh, Pa., from Boeing Co., multimillion-dollar contract for generator and control unit for *Dyna-Soar* manned space glider.

Sundstrand Corp., Denver, from **Boeing Co.,** multimillion-dollar contract for an accessory power unit for the *Dyna-Soar*.

Douglas Aircraft Co., Santa Monica, Calif., multimillion-dollar contract for 22 DM-21 *Thor* rockets for use as boosters in space programs.

Thompson Ramo Wooldridge, Seattle, from **Boeing Co.,** multimillion-dollar contract for research and development work on the *Dyna-Soar*. **TRW's Tapco Group,** Cleveland, will provide *Dyna-Soar's* reaction control power component.

Thiokol Chemical Corp., Elkton, Md., from **Boeing Co.,** multimillion-dollar contract for design and development of an acceleration rocket for *Dyna-Soar*.

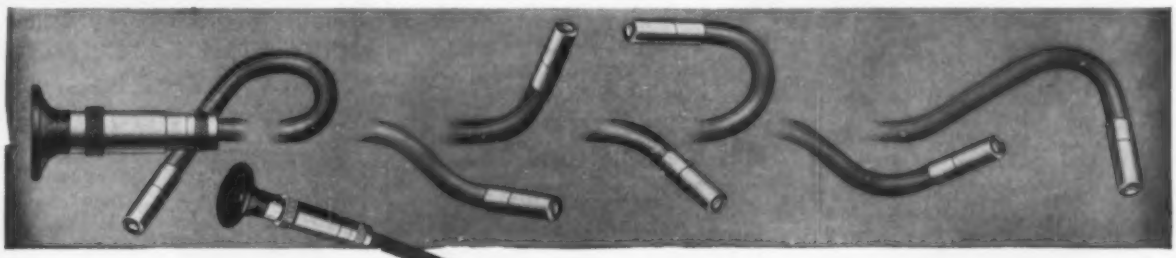
$1,500,000—Budd Electronics, Div. of The Budd Co., L.I., N.Y., for additional TD-285/FST multiplexer units.

$250,000—The Goodyear Tire & Rubber Co., Akron, Ohio, for specially designed tires for the *B-58*.

$100,000—Daystrom, Incorporated, Pacific Division, for flight-control stability-reference gyroscopes for the *Hound Dog* missile. From **Autonetics Div. of North American Aviation, Inc.**

$96,474—Electro-Optical Systems, Inc., Pasadena, Calif., from **Aeronautical Systems Div.,** for research and development of metal bolometer-type infrared detectors for use in extremely accurate tracking and reconnaissance devices.

Melpar, Inc., Falls Church, Va., from **North American Aviation,** for high-reliability circuit assemblies and modules for the *Minuteman* ICBM electronic systems. No amount disclosed.



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JUNE

National Machine Tool Builders' Association, 59th Spring Meeting, Mayflower Hotel, Washington, D.C., June 1.

American Society for Quality Control, Annual Convention, Sheraton Hotel, Philadelphia, June 5-7.

International Instrument Conference and Exhibit, Instrument Society of America, Royal York Hotel, Toronto, Canada, June 5-8.

National Electrical Manufacturers Association, Western Conference, Biltmore Hotel, Los Angeles, June 8-9.

Manufacturing Chemists Association, 89th Annual Meeting, The Greenbrier, White Sulphur Springs, W.Va., June 8-10.

European Federation of Chemical Engineering, Thirtieth Meeting, Frankfort-am-Main, Germany, June 9-17.

American Society of Mechanical Engineers, Statler Hilton Hotel, Los Angeles, June 11-15.

Third National Symposium on Radio Frequency Interference, Institute of Radio Engineers, Sheraton Park Hotel, Washington, D.C., June 12-13.

Instrument Society of America, 3rd International Symposium on Gas Chromatography, Michigan State University, East Lansing, June 13-16.

Joint ARS-IAS Meeting, Ambassador Hotel, Los Angeles, June 13-16.

American Society of Mechanical Engineers, Applied Mechanics Conference, Illinois Institute of Technology, Chicago, June 14-16.

American Rocket Society, Semiannual Meeting, Biltmore Hotel, Los Angeles, June 14-17.

American Society for Testing Materials, Annual Meeting, San Francisco, June 16-21.

IAS Symposium on "Space Flight and Reentry Trajectories," Paris, June 19-21.

Heat Transfer and Fluid Mechanics Institute Conference, University of Southern California, Los Angeles, June 19-21.

American Association for the Advancement of Science, Pacific Division, Annual Meeting, University of California, Davis Campus, June 19-22.

Carbon Conference, Pennsylvania State University, and American Carbon Committee, University Park, June 19-23.

Denver Research Institute of the University of Denver, Eighth Annual Symposium on Computers and Data Processing, Elkhorn Lodge, Estes Park, Colo., June 22-23.

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editorial . . .

Why We Are Going Into Space

SPACE is there. Man will go there.

We present in this issue the arguments against his going as well as those in favor of it. But the outcome is inevitable.

Two men, in fact, already have gone and returned. One was a Russian; the other, American. These first space explorers will be followed by many, many more.

Numerous reasons have been put forward to explain why. These might be grouped into four major theories:

The Hillary Theory. Man will go into space if for no other reason than the fact that, like Mt. Everest, it is there.

The Columbus Theory. The true commercial value of the voyage of Columbus became evident only in retrospective. The same will be true of space exploration.

The Archimedes Theory. Advancement of pure science is more important even than life itself. That as Archimedes, intent upon his mathematics, was killed during Marcellus' sack of Syracuse, so men always will risk all to increase basic scientific knowledge.

The Panama Theory. Powerful military and political needs of the leading nations of the world make it imperative for them to hold dominant areas of space which, like the Panama Canal, are important to national survival.

The last of these is at the moment perhaps the most compelling, although in the long run not necessarily the most important. We must extend our national effort into space because the Russians are going and we dare not let them go unchallenged.

Even if there were no Russians, we would accept the challenge of the stars. Sooner or later, we would go. It is, however, the political-military competition between the United States and the Soviet Union which lends urgency to our space programs.

Our drive to catch up with the Russians is a two-pronged effort, by the military and by the National Aeronautics and Space Administration.

A GLANCE is sufficient to indicate that in neither of these areas is the effort and planning strong enough for our national survival. Only recently has a military mission in space even been recognized. More money, more thought must be given to what we intend to accomplish militarily.

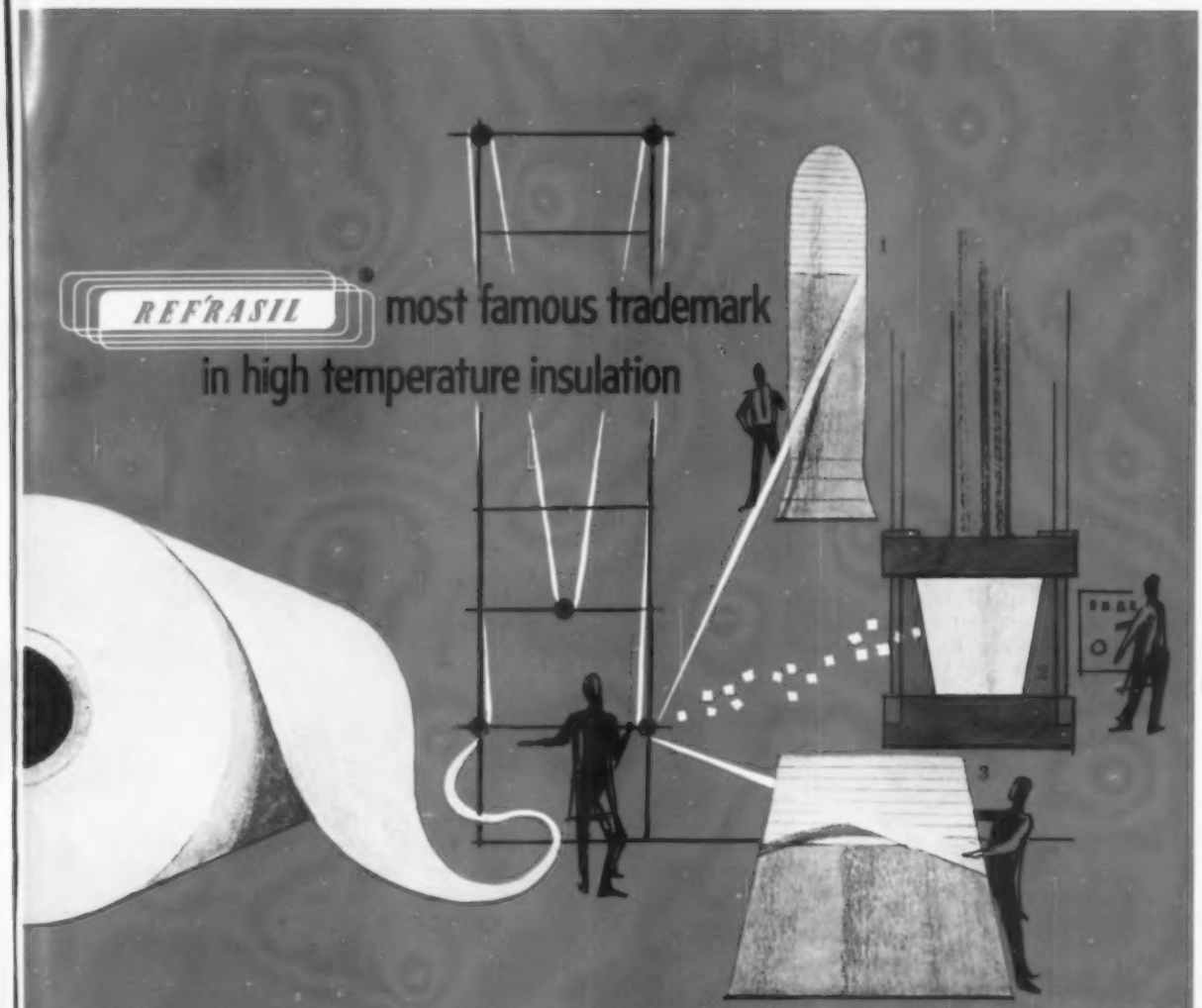
Elsewhere in this issue, you will find NASA answers to four important questions about our space effort submitted by MISSILES AND ROCKETS. The answers indicate a lack of planning by the previous Administration and too little effort by the present Administration to remedy it.

Long before now, a study should have been made of scientific objectives we hope to accomplish in space between the three-orbit *Mercury* flight and the first *Apollo* flights. NASA should know more precisely both what the objectives are and what funding is required to attain them. There is a broad gap between the programs as they now stand.

We have also attempted to point out in this issue some of the technical areas in which further research and engineering now is needed if our space effort is to be successful on a time-scale competitive with the Soviet Union. These problem areas must be tackled immediately.

We cannot afford to be second in this race.

William J. Coughlin



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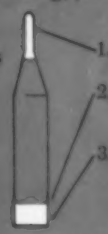

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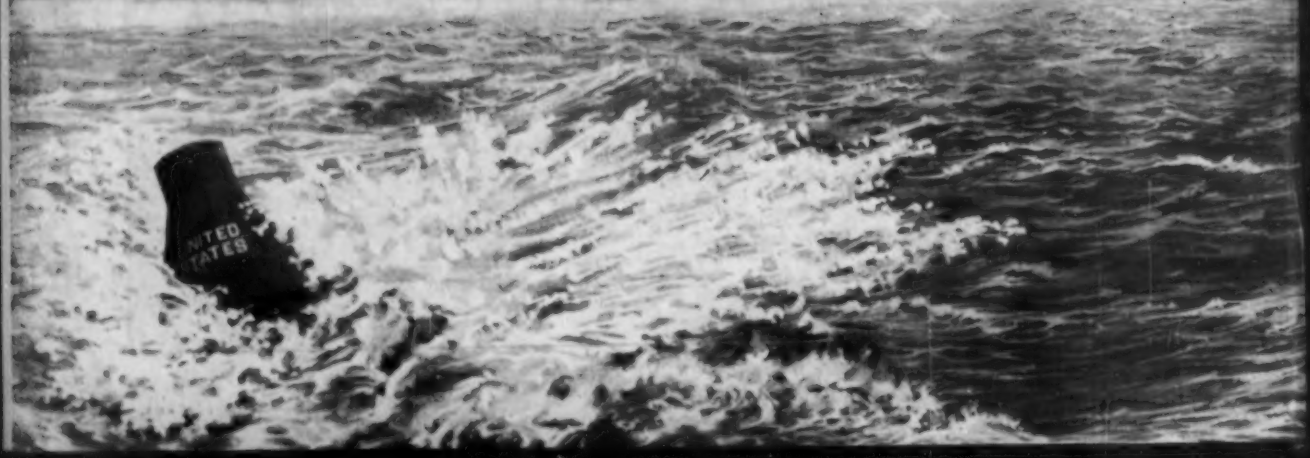
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